# Effective Knowledge Dissemination from Universities: An Evaluation of Technology Transfer Offices and the Environments in which They Operate

by

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*Thesis presented in fulfilment of the requirements for the degree of Master of Engineering (Engineering Management) in the Faculty of Engineering at Stellenbosch University*

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December 2019

# Declaration

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# Abstract


**Effective Knowledge Dissemination from Universities: An Evaluation of Technology Transfer Offices and the Environments in which They Operate**



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Measures of the research that is generated by universities are commonly used to determine the subsidies that governments pay to universities. Universities can also develop research into technologies that can be sold to industry, in order to supplement the income from government subsidies and student fees. In some cases, researchers at universities have to make trade-off decisions regarding whether to focus on publishing the research (to possibly increase government subsidies) or to focus on research that can be sold to industry. Both of these foci may be legitimate ways of disseminating the research done at universities. The purpose of this study is to develop a framework that supports the evaluation of the knowledge dissemination determinants at universities, with a focus on university TTOs and the environments in which they operate.

The framework identifies the concepts relevant to the operation of TTOs that affect knowledge dissemination. The concepts can be grouped into the themes of: (1) Goals of the University, (2) Intellectual Capital, (3) IPR, (4) Funding, (5) Incentives, (6) Info-Culture, (7) Info-Structure, (8) Infrastructure and finally (9) Dissemination.

Two primary case studies, Stellenbosch University and KU Leuven, are conducted using the framework. Secondary case studies are selected to compare the primary case studies to. These secondary case studies include: (1) universities that are located in similar environments, and (2) universities that are similarly ranked, but operate in different environments. The aim is to identify factors and behaviours that increase the effectiveness of knowledge dissemination from universities in these different environments.

This study thus makes two contributions. Firstly, it presents a framework that can be used to evaluate knowledge dissemination determinants from universities. Secondly, it uses this framework to identify various patterns of these determinants and the observed performance related to these determinants in various cases. This adds to the growing literature exploring the determinants of the knowledge dissemination related performance of university.

# Uittreksel

## Doeltreffende Kennisoorgrag Strategieë van Universiteite: 'n Vergelykende Studie van Tegnologie Oordragskantore in die Omgewing waarin dit Funksioneer

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Navorsing wat deur die universiteit gedoen word,is een van die groot elemente wat die subsidies bepaal wat van die regering toegeken word. Universiteite is ook in 'n posisie om met navorsing verder waarde toe te voeg, en te ontwikkel in tegnologie. Dit kan dan die universiteit se inkomste aanvul wat andersins van die regering of uit studente klasgeld uit moes kom. In sekere gevalle kan navorsers by universiteite onderhandel/ besluit om te fokus op publisering van navorsing (wat regering subsidies sal verhoog) of om navorsing na tegnologie te ontwikkel (wat weer in die industrie wins tot gevolg kan hê). Beide hierdie fokuspunte is baie geldige maniere om die verspreiding van navorsing wat by universiteite gedoen word te ontgin. Die doel van hierdie studie is om die faktore te bepaal wat die keuses tussen suiwer navorsing of toepassings in tegnologie vir industrie beïnvloed, asook die effektiewe verspreiding van hierdie kennis aan universiteite oor die algemeen, gegewe die verskillende beleidsrigtings.

Die doel van hierdie studie is om 'n raamwerk te ontwikkel waarin kennisoordrag aan universiteite evalueer kan word, met die uitsluitlike fokus op Tegnologie Oordrags Kantore (TOK) en die omgewing waarin die universiteit werk. Die konsepte wat gebruik word vir die studie is as volg: (1) Doel van die Universiteite, (2) Intellektuelle kapitaal, (3) Intellektuele eiendoms regte, (4) Befonsing, (5) Annmoediginskemas, (6) Inligtingstruktuur en, laastens, (9) Verspreiding van Kennis.

Universiteit van Stellenbosch en KU Leuven was die twee prim êre gevallestudies wat gemeet is aan hierdie raamwerk. Sekondêre gevallestudies is gedoen om univesiteite te vergelyk wat (1) in dieselfde omgewing gelee is en (2) universiteite wat dieselfde rangorde het maar in uiteenlopende omgewings funksioneer. Die doel hiervan was om faktore en handelings te identifiseer wat die effektiwiteit van kennisverspreiding verhoog in die verkillende omgewings.

Die studie maak twee bydraes. Eerstens, vertoon dit 'n raamwerk wat kan gebruik word om die kenis oordrag determinante van universiteite te evalueer. Tweedens, kan die raamwerk gebruik word om verskillende patrone van hierdie determinante, en die waargeneemde optrede in verband met die determinante in die verskillende gevalle. Die vroeg by tot die groeiende literatuur wat die determinante van die verhouding tussen kennis oordrag en die optrede van die universiteite verken.

# Acknowledgements

I would like to express my sincere gratitude to my parents with their endless patience, and my supervisor for his continual support.

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# Nomenclature

**Acronyms and abbreviations**

FTE Full-Time Equivalent
FTO Freedom-to-Operate
GCR Global Competitive Index
GDP Gross Domestic Profit
IFCO Innovation Fund Commercialisation office
IMEC International Medical Equipment Collaborative
IP Intellectual Property
IPMO Intellectual Property Management Office
IPR Intellectual Property Rights
KPI Key Performance Indicator
KU Leuven Katholieke Universiteit Leuven
LRD KU Leuven Research and Development
Leuven Inc. Leuven Innovation Networking Circle
NIMPO National Intellectual Property Management Office
Paris Convention Paris Convention for the Protection of Industrial Property
PCT Patent Cooperation Treaty
MCC Cost of Research and Development
MRRp Private Marginal Rate of Return
MRRs Social Marginal Rate of Return
QCA Qualitative Comparative Analysis
QS Quacquaelli Symonds
R&D Research and Development
THRIPs Technology and Human Resource for Industry Programme
TRIPS Agreement on Trade-Related of Intellectual Property Rights
TIA Technology Innovation Agency
TTO Technology Transfer Office
UN United Nations

| | |
|---|---|
| USA | United States of America |
| WESP | World Economics Situation and Prospects |

# Chapter 1

# Introduction

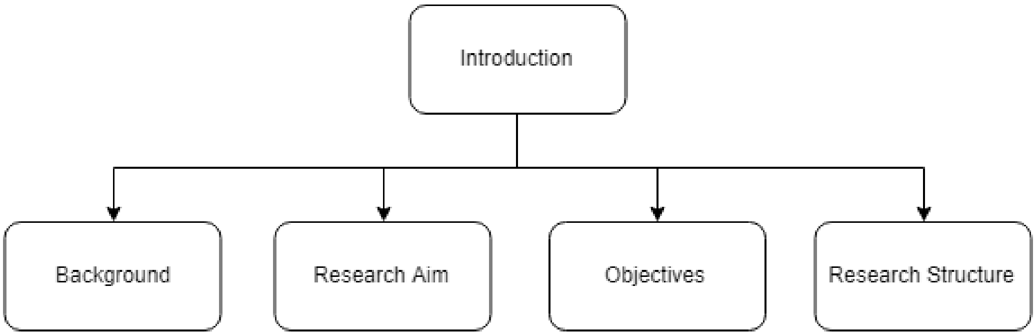


**Figure 1.1:** Overview of Chapter 1

The purpose of the chapter is to explain the problem, clearly state the objectives of the study and identify the steps and the direction that the research project will take. The chapter aims to build a map of the research study. The sections in the chapter aim to accomplish the following:

- Section 1.1 – Background: Provides a summary of the research gap that is identified.
- Section 1.2 – Research aim: States the ultimate aim of the research project.
- Section 1.3 – Objectives: States the objectives that the research project aims to achieve.
- Section 1.4 – Research Structure: Presents an introduction to the research process that will be followed.

## 1.1 Background

Universities, along with the government and industry, are widely identified as the pillars that drive innovation in a country. Although some sources dispute whether universities or industry play the leading role regarding innovation in a country, there is a consensus with regard to the principle that universities play a critical role in innovation (Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2000; Rosenberg and Nelson, 1994; Feinson, 2003). Universities act to further develop, store and distribute knowledge that has been garnered over the centuries. This is facilitated in many ways – from archiving key texts in libraries, to transferring knowledge to students (Faggian and McCann, 2006).

One of the primary methods that universities use to transfer knowledge is through the training of students - particularly undergraduates (Faggian and McCann, 2006). Undergraduate students usually form the largest percentage of students at the university, as they are taught concepts that can generally be regarded as public knowledge and which can often be found in textbooks. The knowledge that is conveyed to the students during this period of study is then implemented into industry through students starting their careers. Students also use the knowledge gained through undergraduate training as the basis for their postgraduate studies (South African Council on Higher Education, 2011).

A university is, however, more than just a collection of historical knowledge. Having access to knowledge resources allows the university to do research and generate new knowledge. Although undergraduate students generally outnumber postgraduate students, additional research and knowledge generation of the university is essential for the success of a university (Guo, 2014; Lincoln Project, 2015).

The generation of new knowledge, in many ways, defines the prestige of the university. Rankings of universities are mainly based on the research done at a university. The research is usually performed through research groups, which consist of staff, lecturers, professors and post-graduate students (Quacquaelli Symonds, 2016; Ewalt, 2015).

Government subsidies and grants are generally the largest contributors to the funding of public universities. In many cases, countries set aside a budgeted amount to spend on university funding (Knight, 2001). Depending on the strategic goals of the government, these funds are allocated according to various formulas or on the basis of certain rationales. Universities are then able to increase their allotted funding by aligning with the strategic aims of the government and, in many cases, by measurably increasing knowledge generation and dissemination – through patents, published articles, number of graduated students, etc. In many cases, one of the measures used in these calculations is the university's number of publications by the university during a given time (Quacquaelli Symonds, 2016; Ewalt, 2015; Innovus, 2016; Xhauflair *et al.*, 2015; Figel, 2012).

Universities can also sell/license research with commercial potential to industry. This can be done by either licensing it to an existing entity, or licensing it to a new company that is created to exploit the technology that was developed, which is referred to as a spin-off or spin-out company. However, the potential to sell/license research needs to be balanced with the need of the university to publish research. This is important, as published research cannot be patented. There is therefore often a trade-off in timing between selling research and publishing research (Cetindamar *et al.*, 2010; Knight, 2001; Hsu, 1996; Shah *et al.*, 2013; Chan *et al.*, 2014; Weber and Bergan, 2005).

Companies in industry can also approach universities to do research for them. This can be done through contract research, or on a consultation basis. In these cases, disclosing the research in publications usually has to be authorised by the company renting the services of the university to conduct the research.

Government funding to universities although reliable, is generally being decreased or kept constant for research institutions. However, funding can be unexpectedly reduced if the country is facing budget constraints. Due to this risk, universities are forced to consider alternative sources of funding, such as the selling of research. The purpose of this study is to evaluate methods universities can best use to manage their roles of knowledge development and knowledge dissemination in different environments. In particular, the research investigates the key differences that drive different behaviours in developed and developing countries (Knight, 2001). Two elements that are considered are the relation to the strategic rationale guiding dissemination policy and how universities can best create incentives for researchers to attain the best possible outcomes.

In the context of this study most of the activities performed at a university result in the dissemination of knowledge into society. Universities are widely regarded to have three missions, (1) teaching, (2) research and (3) social engagement. However, this study has a greater focus on the dissemination of knowledge of research conducted at universities than the dissemination through teaching. Universities have the most freedom in managing the research that is conducted at the university (Baya *et al.*, 2011; Lane, 1999). This is discussed in detail in Chapter 6.

Most of the research conducted as a university is disseminated through publications. There is however a small portion of research conducted at the university that can be commercialised. This knowledge generally passes through the Technology Transfer Office (TTO), and is disseminated to industry.

TTOs have recently been playing an increasingly important role in the management of knowledge dissemination from universities. Furthermore, the method of approaching knowledge dissemination, is greatly influenced by the context within which a university operates. However, few tools exist that enable universities to evaluate their knowledge dissemination practices, including the role of TTO and while also considering the context of the university.

Literature available is focused on evaluating the effectiveness of knowledge dissemination from universities , but based in a specific environment. The literature does not aim to differentiate between two different environment such as developing countries.

## 1.2 Research Aim

The aim of the research is to *develop a framework that supports the evaluation of the knowledge dissemination practices at universities, with a focus on university TTOs and the environments in which they operate. This framework should enable universities to compare themselves against their peers and to appreciate the environmental factors which might influence decision-making in different environments.*

## 1.3 Objectives

To achieve the aim, the following objectives were developed. These objectives have been used to guide the research process. The objectives are as follows:

1. Critically review and analyse literature on methods of exploiting Intellectual Property Rights (IPR's).
2. Critically review and analyse literature the economics of intellectual property and innovation.
3. Critically review and analyse industry-university linkages and impacting factors.
4. Construct a conceptual framework, that supports the identification of the key practices or activities for the dissemination of knowledge from universities given the different environments within which the universities may operate.

5. Validate the framework through subject matter expert interviews.
6. Perform an empirical study using the conceptual framework that was constructed to identify the factors in the universities' environments that determine the definition of effective knowledge dissemination by universities and how it might optimally be achieved.

## 1.4 Research Structure

This research project aims construct a conceptual framework that aims to systematically identify and evaluate existing knowledge dissemination practices at universities, as well as the context within which they are operating. The framework enables the comparison of universities operating in similar and dissimilar contexts, the project follows the steps presented by Jabareen (2009) to develop a conceptual framework. This method is used to identify the concepts that influence universities' knowledge dissemination processes. Hypotheses are also generated with respect to how universities are expected to respond differently to different environments. The data from the selected case studies are then implemented into the conceptual framework – after which this data is used to identify the strategies adopted by the primary case studies, to ensure effective knowledge dissemination.

To test the hypotheses generated for the difference in approach between universities in developed and developing countries, two primary cases are evaluated. These cases are found at Stellenbosch University, as the developing country case, and KU Leuven, as the developed country case. KU Leuven and Stellenbosch University are used because both these universities collaborate strongly with industry in two different environments. In addition to the two in-depth case studies, a concise comparison is also made between the primary case studies and various other universities to better contextualise the two cases within their respective environments. The results from the case studies shed light on the practices that universities implement to support knowledge dissemination in different environments.

The framework that is developed can be used by TTOs for developing key performance indicators. These indicators will be developed based on the environment of the university. The conceptual framework aims to highlight the important aspect that should be considered when setting up key performance indicators.

### 1.4.1 Construction of the Conceptual Framework

Constructing an effective and accurate conceptual framework, according to Jabareen (2009), is done in nine steps. Chapter 4, Chapter 5 and Chapter 6 constitute the literature review used to construct the conceptual framework. In particular, they address the aspects relevant to governing universities' technology transfer. These chapters aim to identify the concepts that impact the transferring of knowledge from a university. Chapter 7 identifies and categorises these major concepts.

Chapter 7 provides the structure of the conceptual framework. Although there were numerous iterations of the conceptual framework, only the final model is presented in Chapter 7. The aim of this framework is to (1) list the concepts that were identified, (2) link the concepts to the literature, (3) identify the influences that the concepts has on technology transfer and (4) identify measurable variables that can be used in the case studies.

### 1.4.2 Data Collection and Analysing of Results

The framework that was constructed will then be compared with case studies. The aim of this section is to (1) identify the expected outcomes of the dependent variables based on the independent variables, and to (2) investigate the unexpected outcomes of the dependent variables based on the independent variables, according to the conceptual framework. Through this process additional concepts were identified, as well as alternative links between dependent and independent variables, and exceptions.

These case studies are incorporated into the conceptual framework to draw conclusions on how the contexts of the university will influence the determinants of knowledge disseminating from universities. The framework was the validated by interviewing various industry experts.

### 1.4.3 Discussion of Results

Chapter 9 discusses the results arising from the implementation of the data into the conceptual framework. This chapter aims: (1) to identify the best practices in the different environments and (2) to evaluate the effectiveness of the framework for assessing the knowledge dissemination practice at universities and the context in which they operate.

The conclusion and recommendations are presented in Chapter 10. This chapter presents a summary of the thesis along with the implication that the study has on common practice and the current research. It also provides suggestions for future research.

## 1.5 Chapter Summary

This chapter provides a synopsis of the outline of the project that is to follow. It provides an introduction to the research gap that is in literature, which is the lack of frameworks focusing on TTOs, comparing knowledge transfer practices from universities based on the different contexts they are situated in. This literature gap will be expanded on in the following chapter, but the background for the study is presented here.

After the research gap has been established, the purpose of the research project is discussed, through the research aim. In short, the aim of the research project is to develop a framework to compare the effectiveness of knowledge transfer from universities in different contexts. This aim is broken down into seven manageable objectives which all contribute to the main purpose of the study.

Finally, the research approach is discussed, which gives an overview of the steps the study followed. The first part of the project focused on the construction, development and validation of the framework. This amounts to the largest portion of the study. Data was then be gathered from two primary case studies, and some secondary case studies, and analysed using the conceptual framework that was developed. Finally, the study will provide a discussion of the results.

# Chapter 2

# Background Literature Review

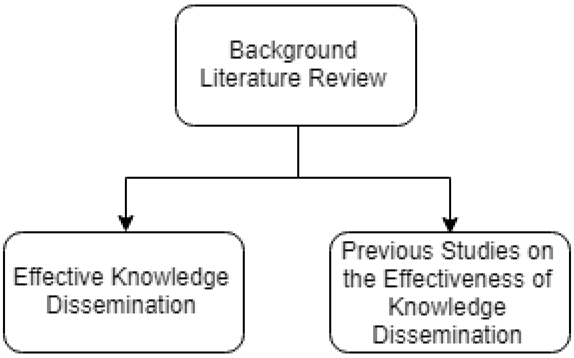


**Figure 2.1:** Overview of Chapter 2

The purpose of this chapter is to provide a short background to the study. The chapter constitutes the following two parts:

- Section 2.1 – Effective Knowledge Dissemination: This section provides some background on why it has become important for universities to effectively manage their knowledge dissemination processes.
- Section 2.2 – Previous Studies on Effectiveness of Knowledge Dissemination: This section identifies previous studies that were conducted on knowledge dissemination and technology transfer in order to highlight the research gap that exists.

## 2.1 Effective Knowledge Dissemination

The process of effective knowledge dissemination involves managing research outcomes of the university to best serve the mission of the institution. The definition of effectiveness is dependent on the status of the university, the context in which the country of the university operates. Each university is unique and receives funding from different sources and through achieving different objectives. For a university to be effective with disseminating knowledge, these objectives has to be reached (Baya *et al.*, 2011; Lane, 1999).

Universities are rich in new knowledge that is produced through research, but opportunities for selling to external entities are limited. For example, Figure 2.2 provides a representation of the faculties of Stellenbosch University, linked to the more common method of exploiting the research that is done within these faculties. All faculties can provide external entities with consultations, as they could be considered to be leaders in that field. Considering Figure 2.2, it can be seen that only the Agricultural Sciences, Engineering, Medicine and Health and Science faculties focus on research that can usually lead to patents or plant breeder's rights. These forms of protection are the easiest to license out (Leyden, 2016; Stellenbosch University, 2009).

The other faculties can consult and even perform contract research for external entities, but the fields of research they operate in rarely produce patentable technologies, or plants that can be protected. For this reason, these faculties rarely have to make the distinction between patenting and publishing. However, they do still have to refrain from publishing when the research is conducted in collaboration with certain external entities that place restrictions on public disclosure.

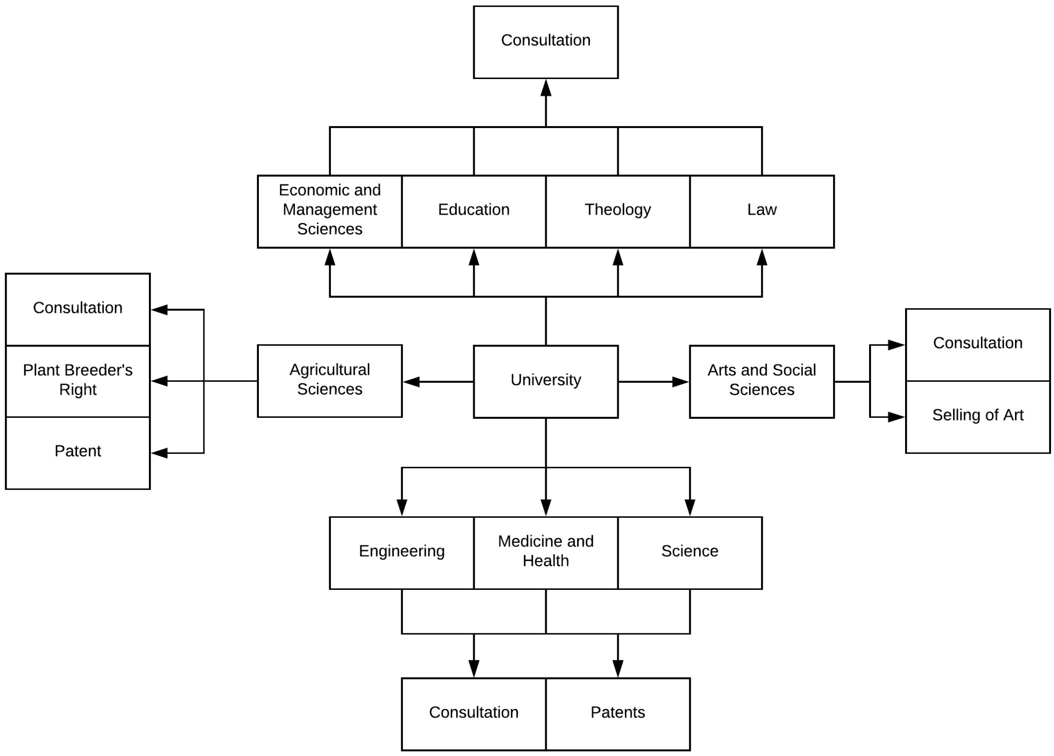


**Figure 2.2:** Preferred knowledge exploitation pathways (excluding publication) for different faculties at Stellenbosch University *adapted from* Leyden (2016) and Stellenbosch University (2009)

Figure 2.1 uses the data presented by the financial reports of the universities (Stellenbosch University, 2016; ETH Zurich, 2016; University of Cape Town, 2015; Torfs, 2016; Controllers Office, 2015; Controller's Office, 2016; University of Witwatersrand, 2016; Ponhang University of Science and Technology, 2014) to provide an indication of the income available to universities through their interactions with industry. It must be noted that Ponhang University of Science and Technology is a private university that is solely focused on engineering and science. Therefore, a larger percentage of the research done at the university is eligible for selling.

| University | Percentage income from industry | Reference |
|---|---|---|
| Washington State University | 13% | (Controllers Office, 2015) |
| Univesity of Witwatersrand | 6% | (University of Witwatersrand, 2016) |
| KU Leuven | 17% | (Trofs, 2016) |
| University of Cape Town | 35% | (University of Cape Town, 2015) |
| University of Zürich | 18% | (ETZ Zürich, 2016) |
| University of North Carolina at Chapel Hill | 1% | (Controllers Office, 2016) |
| Stellenbosch University | 23% | (Stellenbosch University, 2016) |
| Ponhang University of Science and Technology | 54% | (Ponhang University of Science and Technology, 2014) |

**Table 2.1:** Percentage income from interactions with industry

The above examples illustrate the diversity of choices that can be made in terms of managing knowledge exploitation at universities and how different circumstances can influence the optimal combination of exploitation alternatives. The next section explores the existing studies that researched these and other aspects related to the knowledge dissemination from universities.

## 2.2 Previous Studies on Knowledge Dissemination

Knowledge dissemination, for the purpose of this study, centres around the transferal of knowledge from the university to the public in the most effective manner possible from the perspective of the university. There are numerous avenues of knowledge dissemination to the public, which include informal knowledge transfer, consultations, contract research, licensing, publishing and teaching. The final output, however, is limited to the general public or a specific external entity, whether that entity is a company, the government or another university.

The aim of the university's policies and processes regarding the management of intellectual capital should be to select the output that will be most effective. For example, the publication of a technology that has the potential for high income through licensing would be an ineffective way of transferring knowledge. Another ineffective method of knowledge transferal would be to patent an invention that has very little to no commercial value, especially in a university setting. It would be more effective to publish these inventions, and to use them to elevate entities that would find value in the research. This type of disclosure is also generally encouraged by governments through grants and subsidies as it increases the knowledge available to the general public.

The study aims to identify effective methods of disseminating knowledge from the research that is done at a university. Even though only a small portion of the research done can be sold to an external entity, this research, ideally, should be managed by the Technology Transfer Office (TTO) (Hockaday, 2013).

Upon investigating previous studies related to this topic, it was deemed appropriate to focus the present study on models that were constructed for identifying effective TTOs. This topic is a popular one since numerous articles have aimed to identify methods to improve TTO effectiveness because it constitutes a source of additional funding.

The TTO is the department or entity that manages the relationships between the university and external entities, such as industry, government, other universities or other TTOs, in regards to the commercialisation of research. In the past, building and maintaining relationships was the primary goal of the TTOs, but more recently, the focus of TTOs has shifted towards managing the technologies that originate from the university (Hockaday, 2013).

As research that results in technology generation has the potential to generate additional funds, the TTO has to identify barriers and create incentives to ensure that this type of research is increased (Geuna *et al.*, 2008). When searching for previous research done on the subject of effective knowledge dissemination from universities into industry, most research seems to focus around the TTO, as they are the key liaison between the university researchers and industry (Hockaday, 2013).

In this study, both Web of Knowledge and Scopus was used to identify the relevant literature. The key words that where used for identifying similar studies was "knowledge dissemination" and "technology transfer" in conjunction with terms such as "model", "framework" and "conceptual framework". Terms such as "effective" and "key performance indicators were also used.

Geuna *et al.* (2008) focuses on the role that the university administration plays in governing knowledge transfer from researchers to the industry. The focus falls mainly on the use of spin-off companies and collaborative research projects between the university and industry. In this research, they assumed that there are some forms of knowledge transfer, exchange of human resources, publishing, consulting, and conferences, which the impact on industry can be difficult to measure. These forms of knowledge dissemination are rarely measured, as is evident from the lack of literature on these subjects. Another assumption in this study is that despite the relevance of tacit knowledge flows and information contracts between a university and industry for the purpose of knowledge transfer, most empirical evidence on university activities related to knowledge transfer to industry focuses on patents, licences and spin-offs.

The study conducted by Geuna *et al.* (2008) concluded that in order to ensure that there is effective knowledge transfer from the university, the TTO needs to act as a bridge between the two different cultures found in industry and in the academia. With regards to the negotiation of agreements between these two entities, Geuna *et al.* (2008) concluded that it is more important for universities to be flexible in negotiations and build relationships than it is to come to an agreement that favours the university. The policies highlighted in this study to have an impact on knowledge transfer are those that rewards faculty participation in the process of knowledge transfer process. This study is focused only on universities that are based in Europe. (Geuna *et al.*, 2008).

Universities are considered to have three missions, or pillars; research, teaching and, as is referred to by Secundo *et al.* (2017), social engagement. This third mission assumes a supporting role to both teaching and research. In the case of the research pillar, as this is the main source of the "new" knowledge that is transferred. Technology transfer activities, university licensing, science parks, incubators, university spin-offs, technology orientated start-ups, collaborative research, contract research, consulting services, technology licensing, graduate education, advanced training for enterprise staff, exchange of research staff and formal and informal information transfer with the external industry environment all fall under a university's third mission activities. The goal of the study conducted by Secundo *et al.* (2017) was twofold: (1) identify the most relevant third mission activity for which indicators are defined and (2) measure these activities in terms of intellectual capital. A conceptual framework was constructed to evaluate and select these activities.

The development of the conceptual framework and a system of indicators was done by first completing an extensive literature review of the subject. The information yielded by the literature review was then used as a baseline from which the workshops were held and the conceptual framework was further developed incorporating opinions of different experts in the field. When the framework was designed, it was sent to be reviewed by numerous representatives of different universities in Europe. The indicators were divided into the following groups: (1) University Specific Indicators, (2) Mission Specific Indicators, (3) Country Specific Indicators and (4) Common Generic Indicators. The indicators that are used in Secundo *et al.* (2017)'s study could be used in this study, as they have been used and tested. The major limitation of the study is that it is also focused solely on European Universities (Secundo *et al.*, 2017).

A study conducted by Gregorio and Shane (2003) focus on only one aspect, i.e. increasing the number of spin-off's generated by the university. This study focused on four areas that influences the rate and success of the spin-off companies generated by universities. These areas are: (1) Availability of venture capital funds in the university area, (2) Commercial operation of university research and development, (3) Intellectual eminence, and (4) University policies.

The variables that were selected were divided into (1) dependent variables, such as the number of TTO start-up's, (2) predictor variables, such as venture capital availability, commercially orientated research, intellectual eminence, university policy licensing and (3) control variables, such as the number of inventions, number of technology licensing office staff and sponsored research expenditures (Gregorio and Shane, 2003). These variables will be used as a guideline for selecting variables and assigning them to a purpose in this study.

Gregorio and Shane (2003) concluded that universities that are more invested in the spin-off companies ensure a higher output of spin-offs as well as a higher success rate, than when a university gives the inventor a higher percentage of ownership. The limitation of the study by Gregorio and Shane (2003) is that it focuses primarily on macro-level factors (technology regimes, strength of patent protection, universities' intellectual property, and human resources policy) and ignores the micro-level factors (attributes of the technological inventions, Inventor's career path experience, their psychological make-up and their research skill). It should, however, be noted that the micro-level factors are difficult to measure, and were not included in the any of the other studies mentioned in this section.

Related to the study conducted by Gregorio and Shane (2003), Bray and Lee (2000) focuses their investigation on the effect of universities providing a license for the use of the technology in exchange for equity in the new spin-off company. The study focused on the financial return that universities are likely to receive by allowing equity redistribution for services. The conclusion of the study is that providing a license in exchange of equity is favourable in most situations. The most common exceptions when the traditional licensing of technologies for cash would be preferred is when the invention is not suitable for a spin-off company, or if licensing the invention will create an immense return on investment. This study has already identified one element that assists with effectively disseminating knowledge.

O'Shea *et al.* (2008) aimed to explain the different aspects of university spin-off behaviour. A conceptual framework was constructed to group the concepts to identify the impact of different behaviours. The categories of these concepts are (1) Personal entrepreneurial attributes, (2) Organisational determinants of university spin-off activity, (3) Institutional determinants of spin-off activity, (4) External determinants of spin-off activities, (5) Development and performance of university spin-offs, and (6) Economic impact of spin-offs. In the conclusion of the study, a summary is given of the impact that behaviours in these different categories have on the spin-offs.

Francis *et al.* (2009) conducted a study surrounding the information security policies of universities, focusing on identifying best practices for the structure and content. The research focused on two primary objectives: (1) to critically analyse the overall structure of information security policies, particularly in terms of the number of policies in use and how these relate to each other and to low level standards and procedures and (2) to investigate the variety of specific issues that are explicitly covered by information security policies. The information was gathered by dividing the data into four groups: (1) University details, (2) Policy structure, (3) Policy administration, and (4) Policy coverage. This study is focused on the protection of information of the university, so it gives an overview of the protection that is required by the university. This study gives an indication of how to measure the effectiveness of protecting intellectual property.

The study conducted by Swamidass and Vulasa (2009) determined the impact that an under staffed TTO would have on its effectiveness. The focus of the study was on the concept that a patent does not generate value, but that it only generates value when it is licensed (in the case of a university). The study discusses the importance of having non-legal, full-time employees in the employ of the TTO. Some TTOs employ numerous legal staff, but fail to see the importance of employing market specialists, financial advisers etc. which would ensure the success of the invention.

Leyden (2016) considered joint research ventures between universities and industry, focusing primarily on the profit-maximising approach for companies. A framework was developed that was used for evaluating the policies to determine the impact it had on the success of these joint research ventures. The study concluded that universities can play a significant role in the innovation process of joint research ventures if they are invited into the venture. These invitations are usually only presented for larger innovations, as the smaller innovations can be developed internally. Building relationships between the TTO and companies can increase the number of invitations, as the companies are then aware of the research that is being conducted at the university.

The aim of the study conducted by Beer *et al.* (2018) was to formalise a mechanism through which best practices can be identified and shared between different TTOs. These best practices were focused around managing human resources, the IP strategy of the TTO, networking, university-industry linkages, the technology that is sold and the organisational design and structure. The study also looked at the constraints of sharing best practices that are inherent in specific scientific disciplines.

The objective of the study by Mohayidin *et al.* (2007) is to evaluate the level of practice among the academics in regard to knowledge management, and to determine the factors that contribute to the effectiveness of knowledge management practices at individual, faculty and university levels. Mohayidin *et al.* (2007) used factor analysis to determine which elements were affecting the practices of knowledge management and multiple regression analysis to determine the importance of various variables in their adding value and improving universities. However, this study focused solely on universities in Malaysia. The variables were divided into three sections, (1) Data, information and knowledge, (2) Infrastructure, info-structure and info-culture and (3) Effectiveness of service, goals of the university and feedback. The study finally concluded that the important factors that shape knowledge management initiatives are info-structure support, infrastructural capacity, info-culture and knowledge acquisition, generation, storage and dissemination.

Weckowska *et al.* (2015) aimed to determine the effect of legislative frameworks on the simulation of local practices for the management and exploitation of IP, which would in turn determine the level of academic patenting. The indicators that were used in the study were divided into (1) Size indicators, (2) Patent output indicators, (3) IP management and exploitation practices indicators, and (4) Expanded developmental periphery indicators. These were all used to conclude that a wider range and earlier development of local IP management and exploitation practices are accompanied by higher levels of academic patenting and the increasing similarity of IP practices is associated with decreasing differences in patenting outputs. Also, the preliminary cross-country analysis revealed an expansion in increasing similarity of practices for IP management and exploitation in countries with different national IP framework histories.

Furthermore, the aim of the study conducted by Siegel *et al.* (2004) was to improve the understanding of TTOs by identifying the key organisational issues that promote successful knowledge transfer. The study followed an inductive qualitative approach, to first identify the barriers to the transfer of knowledge between universities and industries. The study also identified the actions, primary motives, secondary motives, and organisational culture of all the different stakeholders regarding knowledge transfer. The study concluded that there are numerous impediments to the effectiveness of a TTO, the most notable of them being the cultural and informational barriers between the three key stakeholders, the TTO staffing and compensation practices and faculty members circumventing the formal TTO process. The study also found that contrary to popular belief, there is evidence that involving researchers with TTOs can increase the quality and quantity of basic research.

From the above review, there is a rich and growing body of literature evaluating the various aspects that support the performance of TTOs in their quest to better transfer knowledge to industry and the broader public to best advantage the university. It thus seems that there is an emerging opportunity to consolidate this rich and emerging literature into a single assessment framework that enables the systematic consideration of this variety of factors. Furthermore, there appears to be a particular gap for evaluating how the optimal behaviour of a TTO might be influenced by the environment in which it operates, specifically in terms of the level of development of the country in which it operates. This study thus aims to 1) integrate the rich literature in the field to develop a consolidated framework of the key variables that influence knowledge transfer (with a focus on TTOs) and to 2) investigate how these are different in developed and developing county contexts.

## 2.3 Chapter Summary

This chapter aims to serve a single goal, and that is to provide background to the study that will follow. The first part aims to define effective knowledge dissemination, and the second part gives a summary of the literature that has been conducted on the subject. This presents a foundation from which to build the conceptual model.

From Chapter 2, it can be seen that there is no fixed definition for "effective knowledge dissemination" from universities, as it is highly dependent on the context. It can be seen that effective knowledge dissemination differs drastically, even between faculties in the same University. TTO is a widely studies subject, but there is a tendency to assume that all universities operate in the same context.

# Chapter 3

# Research Methodology

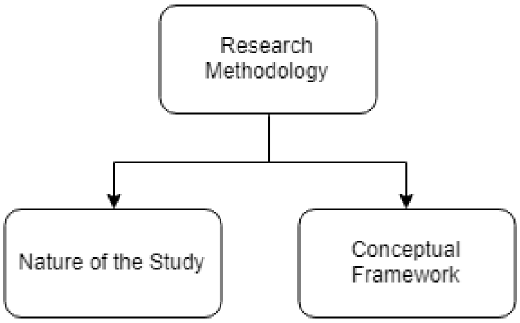


**Figure 3.1:** Overview of Chapter 3

The purpose of the chapter is to describe the research method followed in the study. The chapter presents the steps taken in the study to ensure that the research was performed effectively. More importantly, the chapter aims to present the steps taken in the research to ensure that the conclusions drawn at the end of the study are accurate and repeatable.

The purpose of each section in the chapter, as is shown in Figure 3.1, is as follows:

- Section 3.1 – Nature of the Study: This section identifies the study as a qualitative study, and describes the steps taken to ensure that the conclusions drawn are accurate.
- Section 3.2 – Conceptual framework: This section highlights the process that was followed to ensure that the framework development is sound, specifically focusing on the method laid out by Jabareen (2009).

## 3.1 Nature of the Study

The study will focus on policies put forward by the university to create incentives for generating research that can be sold, but also, policies for strengthening relationships with industry as this could be expected to result result in more funding and research contracts. The data collected from policies provides an indication of how the universities aim to shape the focus and direction of the researchers working at these institutions. These theories are generated through the study and not tested as exhaustively as in quantitative studies. The research is therefore exploratory in nature. When conducting qualitative research, there are four primary considerations to bear in mind, – as stated by Bryman *et al.* (2014):

1. Measurement: To ensure that the concepts are valid and reliable, an instrument needs to be constructed for measurement.
2. Causality: The cause of a phenomenon is a much higher priority than the effect.
3. Generalisation: The conclusions of the study must be generalised to apply to most situation.
4. Replication: This is essential, as the conclusions drawn, must be reproducible in other cases.

The study follows the methodology used by Bryman *et al.* (2014) and extends this by following the conceptual framework design methodology proposed by Jabareen (2009) to develop the conceptual framework used for the analysis of the case studies. The following section (Section 3.2) details the steps followed in alignment with the methodology proposed by Jabareen (2009).

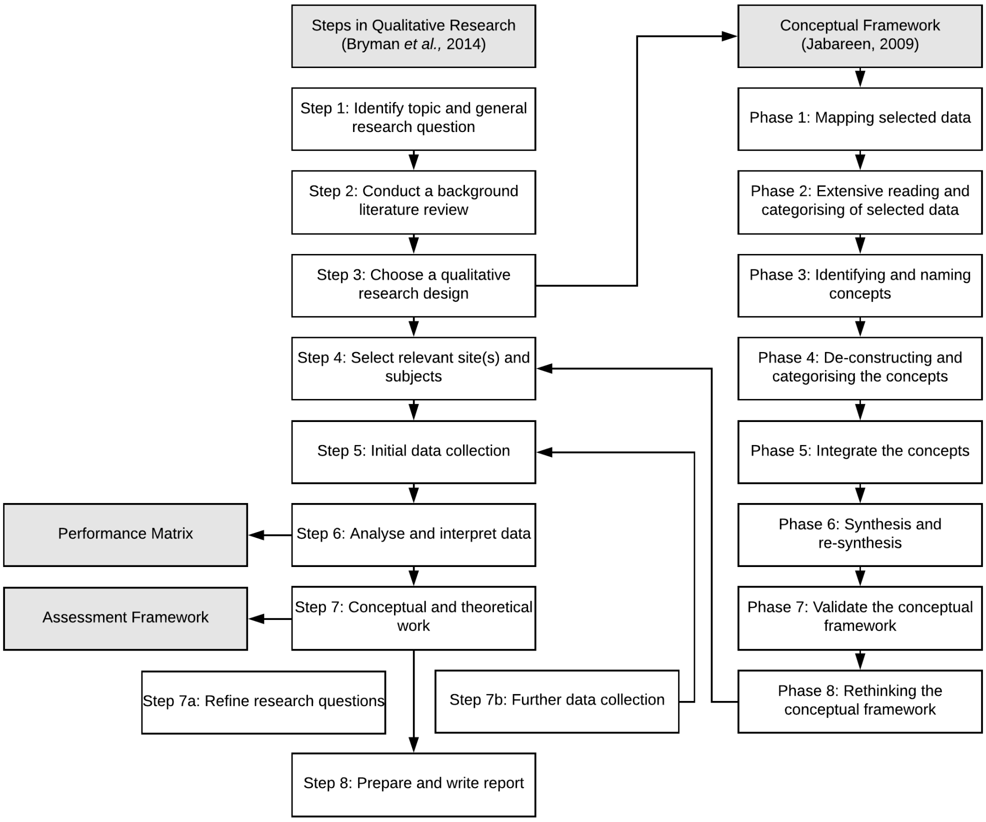


**Figure 3.2:** Research Methodology

## 3.2 Conceptual Framework

This study highlights different concepts related to the exploitation of new knowledge. These concepts are compiled into a conceptual framework, as presented by Jabareen (2009). A conceptual framework is defined by (Jabareen, 2009) as a network of concepts that interlink to create a comprehensive understanding of a phenomenon or phenomena.

***Phase 1: Mapping selected data sources***

The first phase consists of mapping the spectrum of multidisciplinary literature regarding the phenomenon in question. Data sources were identified which explain the phenomenon or phenomena. The data sources used were mostly text based. An extensive search was conducted of multidisciplinary texts, ensuring that all concepts were covered.

Literature for the research review was collected through the Stellenbosch Research Library database, Scopus and Web of Science. The keywords used included intellectual property management, technology management, dissemination of knowledge, technology transfer, publication incentives, key players in technology transfer, university-industry linkages, as well as collaboration and success factors in technology transfer.

***Phase 2 and Phase 3: Extensive reading and categorising of the selected data, and identifying and naming concepts***

Phase two consisted of reading the selected data, and organising it by both discipline and importance. This process maximised the effectiveness of the concepts, and ensured that the important ones were selected and that non-essential concepts were eliminated.

Phase 3 involved reading and rereading the collected data so as to "discover" concepts. The expected results are a list of concepts that compete with and sometimes even contradict one another. These processes allowed concepts to "merge" the literature and the data collected.

Key coding was performed using Atlas.ti, identifying subjects such as: phase of technology development, the economic influence of intellectual property and innovation, national innovation models, the boundary limits of intellectual property rights and how to exploit them, linkages between universities and industrial entities and success factors for technology transfer. The literature for these subjects was identified and broken down into narrower concepts. These concepts were then categorised chronologically as they were discovered.

***Phase 4: De-constructing and categorising the concepts***

The aim of phase four was to clarify the concepts that were selected. The concepts were de-constructed to identify their main attributes, characteristics, assumptions and roles. The results of this phase constitute a table that lists each concept. The table depicts four aspects:

1. Name of the concept
2. Description of each concept
3. Categorisation of the concept
4. Reference of the concept

Once the details of the concepts were known, they were categorised. Concepts were categorised according to each individual role, which could be ontological, epistemological or methodological. This process made the integration of the concepts easier, as all similar concepts were categorised together.

The concepts that were "discovered" in phase 1, 2 and 3 were built into a table. In total, two-hundred-and-five (205) concepts were identified in the literature study.

The descriptions of the concepts are divided into four columns: main attributes, characteristics, assumptions and the role of the concept. Every concept was given a main attribute, and an attempt was made to list the characteristics and the role of all the concepts. Not all the concepts were found to have identifiable characteristics or roles, but at least, one or the other was identified.

***Phase 5: Integrating the concepts***
The fifth phase aimed to combine similar concepts. This combination process reduced the number of concepts used in the conceptual framework and in doing so, the differences between the concepts were clearly highlighted.

The categorised concepts were integrated, reducing the number of concepts to eighty-seven (87) and reducing the categories of concepts to nine as is listed below

1. Goals of the University
2. Intellectual Capital
3. Intellectual Property Rights
4. Funding
5. Incentives
6. Dissemination
7. Infrastructure
8. Info-Structure
9. Info-Culture

***Phase 6: Synthesis, re-synthesis and making sense of it all***
The aim of the sixth phase was to create the "first draft" of the conceptual framework. This process involved the repeated reworking of the conceptual framework to ensure that the final framework made logical sense.

Once the final categories had been selected and were in place, the model was arranged and re-arranged to include all the concepts deemed significant. These concepts highlighted all the important aspects of technology transfer and knowledge dissemination.

A summary of each of the concepts is given, as well as how they relate to the other concepts. More importantly, this summary describes how these concepts could influence university policies. Furthermore, these concepts describe the best practices that are used in universities.

***Phase 7 and Phase 8: Validating and rethinking the conceptual framework***

The framework was validated by having interviews with numerous experts in the field, as can be seen in the Appendix. Their feedback was then implemented into the framework, and the framework was used to evaluate the primary case studies that were selected, and using the secondary cases studies as a benchmark.

## 3.3 Chapter Summary

In this chapter, the nature of the study is identified, namely a qualitative study. A qualitative study, although useful, can have significant drawback, one of which is that the conclusions drawn from the data is an interpretation of concepts. Four elements that must be considered, namely (1) Measurement, (2) Causality, (3) Generalisation and (4) Replication through all the steps of developing the conceptual framework.

This chapter also discusses the steps followed for constructing a conceptual framework, which is proposed by Jabareen (2009). An overview of how the steps for constructing a conceptual framework is implemented into a qualitative research plan is also given. The chapter also discusses the tools and key phrases that were used to develop the framework.

# Chapter 4

# Literature Review of Intellectual Property Rights Protection and Exploitation

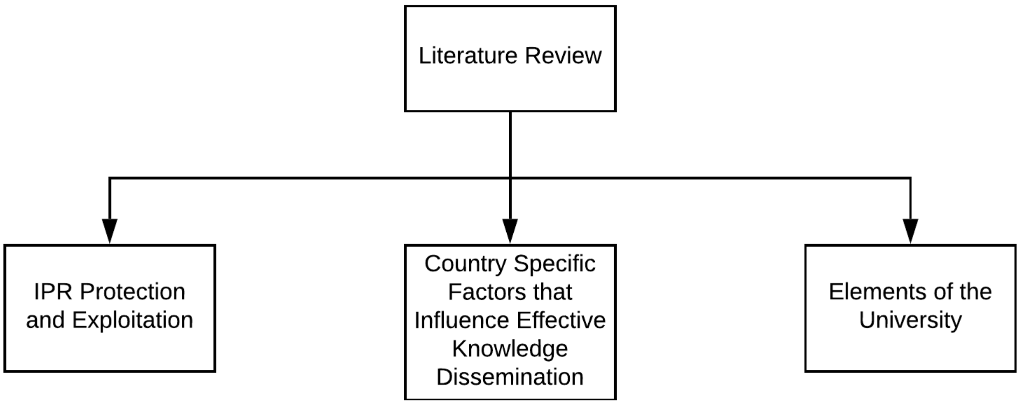


**Figure 4.1:** Overview of the literature review

The purpose of the literature review was to identify the actions that are taken to effectively disseminate knowledge in different contexts. The literature review was divided into three chapters.

- Chapter 4 – IPR Protection and Exploitation: This chapter aims to identify different IPR protection strategies, and how they influence knowledge dissemination as a whole. This is done with a view to elucidating the process for both commercial entities and academic institutions.
- Chapter 5 – Country-Specific Factors that Influence Effective Knowledge Dissemination: This chapter aims to identify the elements of the coun-

try that influence the effectiveness of knowledge dissemination from a university. The chapter also aims to clearly state how developed and developing countries may be differently defined.

- Chapter 6 – Elements of the University: This chapter aims to identify the properties of universities that influence the effectiveness of institutional knowledge dissemination.

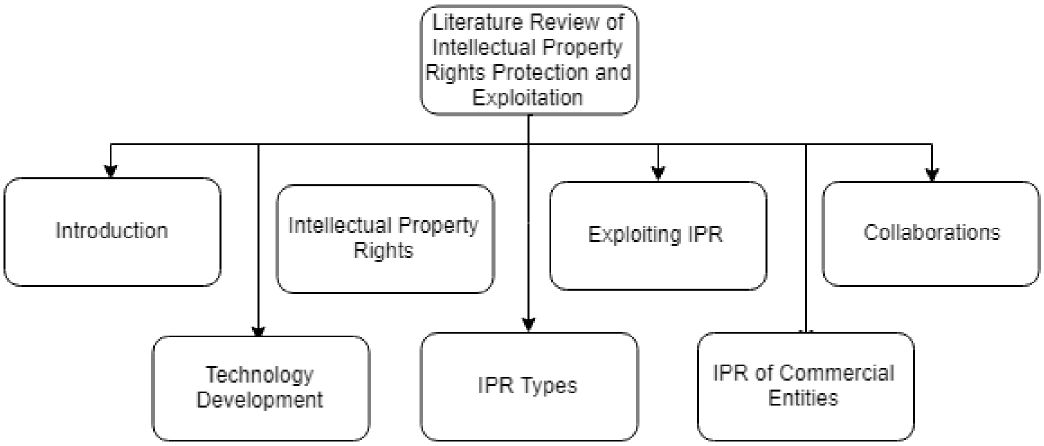


**Figure 4.2:** Overview of Chapter 4

This chapter forms the first part of the literature study, and aims to identify the IPR options and laws that govern the country's knowledge dissemination. The chapter is structured as follows:

- Section 4.1 – Introduction: An introduction to the importance, history and place in society of IPR.

- Section 4.2 – Technology Development: The section aims to highlight the different phases of a technology's life cycle. The section breaks the Research and Development (R&D) phase of the technology's life cycle into different stages, as there are different strategies available depending on how far a technology has been developed.

- Section 4.3 – Intellectual Property Rights: This section discusses the importance of IPR and how it has become a more integral facid of society in the last few years.

- Section 4.4 – IPR Types: Summary of different IPR's available to protect innovative creations. The full explanation and literature review is done in Appendix A.

- Section 4.5 – Exploiting IPR: The generation of an IPR is not the creation of value. This section discusses the power that is bestowed upon and the strategies that are used to exploit the ownership of IPR.
- Section 4.6 – IPR of Commercial Entities: This section elaborates on strategies that commercial entities use for the exploitation of IPR. It discusses the strategies used by commercial entities to ensure that their innovations remains protected.
- Section 4.7 – Research Collaborations: This section identifies the advantages and limitations of collaborating with different entities.

## 4.1 Introduction

Humankind has always used technologies as a response to mitigating the effects the harsh natural environment (Flatt, 2015). Their ability to develop technology is essentially what has always given the human race its advantage in the world. As with nature, the businesses with better technologies will thrive over their competitors who are unwilling to adapt (Ramey, 2012; Roman, 2015).

Without a formal system for protecting innovations, the development of new technologies will be hindered. With no protection systems in place, inventors will rarely share their secrets, and others will not be able to learn from the inventor's successes or mistakes (Belleflamme and Peitz, 2010).

If an innovation is successful, the inventor will be able to produce a product at a lower cost, or higher quality, which will give the inventor an advantage over its competition. As the owner of the innovation will have a monopoly on the new technology, the owner will be able to charge a premium price for the product. On the other hand, the inventor could decrease the price to capture a greater share of the market (Belleflamme and Peitz, 2010).

However, without formal IPR protection, the invention could be copied by its competition without any repercussions. If the competition can copy the invention, there will be very little return on the investment made by the inventor. The result of this "lacking system of protection" is that people would make a new discovery and keep the knowledge to themselves. In this way, they would be the only ones to benefit from an innovation. This will give the inventor an economic advantage, but society as a whole would not progress optimally because the technology would not move forward, due to the new development not being shared with society. Also, the inventor would have to hide the innovations to ensure that competitors do not copy their works.

The first record of protecting intellectual property was in the Greek city of Sybaris, in 510 B.C. The leaders in Sybaris declared that if a cook invented a new dish, no other cook would be permitted to prepare that dish for one year. During this time only the cooks could reap the commercial profits from the dish. This motivated others to work hard and compete by coming up with new dishes (Yonge, 1854; Williams, 2015). Having this recipe in the open also allowed other cooks to taste new combinations of flavours, and might have given them ideas for a different recipe. The cooks benefited through monetary gain, and the rest of society benefited by having the new favourable foods on the market. It also gave new ideas to other cooks, who in turn implemented these ideas and flavours in their own recipes.

This is the basis of any intellectual property rights system. It allows an inventor to benefit from the developed innovation, and it allows society to benefit by availing the knowledge of what was developed to the public. Without IPR protection, innovation would be significantly less, as there would be no protection for an investment made in an innovation or R&D (Lemley, 2015).

## 4.2 Technology Development

Technologies are continually improving; introducing new, better, faster, less expensive, cleaner and more environmentally friendly ways to solve problems, and causing old technologies to become obsolete. For the purpose of this report, a technology will refer to any invention or improvement of a process, or any industrial application – such as a computer program – that is created (Cetindamar *et al.*, 2010).

The life cycle of a technology can be conceptualised by considering Figure 4.3, which was adapted from the work of Beck (2013), Park *et al.* (2015) as well as Cetindamar *et al.* (2010). Section 4.5 elaborates on the exploitation of technology in the different phases of its life cycle. In this section the discussion is limited to the stages of the research and development process.

Figure 4.3 shows the relationship of business gain to the phase of the technology. During the R&D phase, the investment will be high with no sales, and therefore no return on investment. During the ascent phase, the technology is brought to market, and is sold. As it gains popularity, the business gains will increase. At one point the technology will reach maturity, and there will no longer be an increase in sales. At this point the technology would have reached its climax, and will be in the maturity phase. Finally, the technology will decrease in popularity, due to, inter alia, replacement technology or a saturated market.

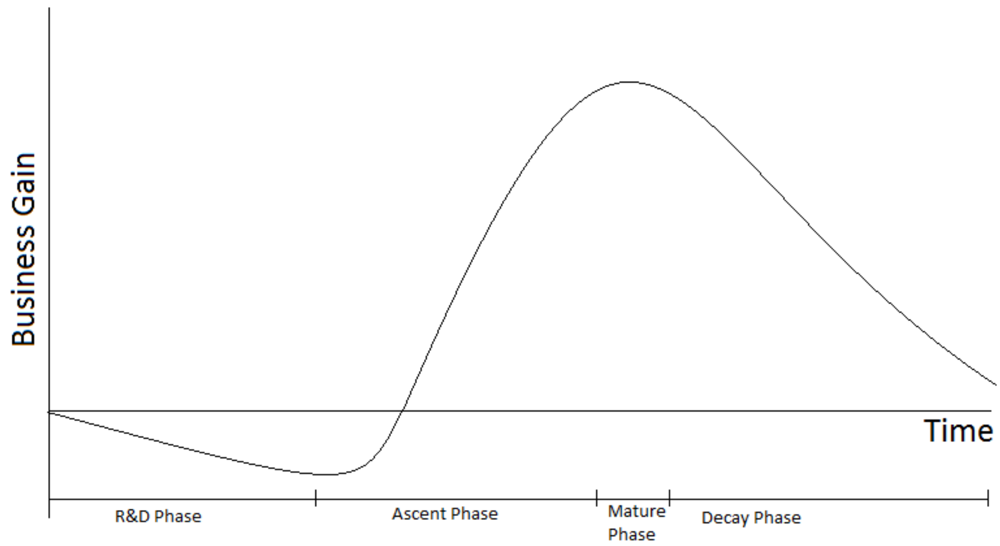


**Figure 4.3:** Technology life cycle *adapted from* Beck (2013), Park *et al.* (2015) and Cetindamar *et al.* (2010)

The R&D phase of a technology includes the whole process from identifying the need for the technology up to the point that the technology is ready to be sold, or implemented. This includes all the research, development and testing activities required for the technology. Any R&D activities undertaken by companies will be the source of some financial strain, as will be discussed in Section 5.1.

A study conducted by Bains (2004) on the development of drugs in the pharmaceutical industry shows the development of a drug through the R&D stages. Pharmaceutical companies develop new products often, but these companies are also plagued by a high failure rate of their products. Figure 4.4, which is derived from the study done by Bains (2004) on R&D in the pharmaceutical sector, shows that only about 14% of the initial ideas become products that are put to market. Companies in other markets may not have such high rates of failure, but failure of technologies in the R&D stage is still high. It is also important to identify technologies that will fail as early in development as possible, as the longer the technology is under development, the greater the loss will be if the technology fails (Rogers, 1995).

Research and development, in general, can be divided into two types which is mainly basic research and applied research. Each type has a specific function, and will be pursued by entities depending on the business strategy of the

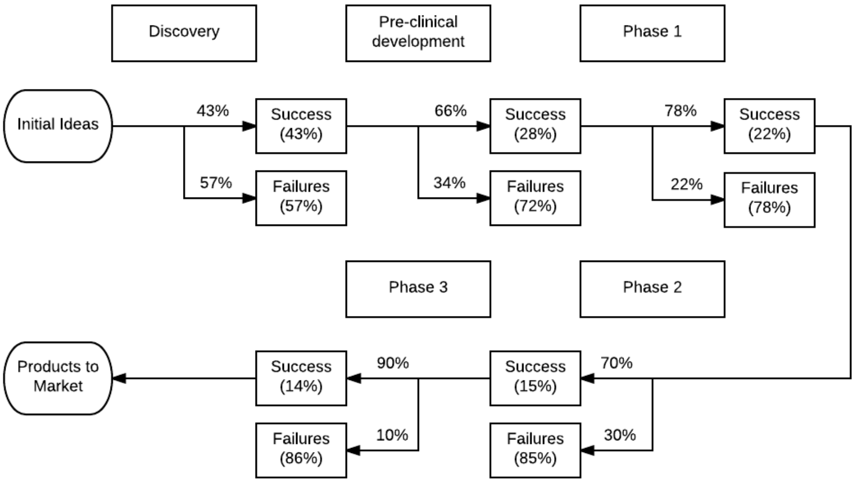


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**Figure 4.4:** Success of ideas in a pharmaceutical company *adapted from Bains (2004)*

entity.

Basic research, as is defined by Parker (1984), is the "fundamental theoretical or experimental investigation to advance scientific knowledge, immediate practical application not being a direct objective". The aim of basic research is to improve the general theoretical understanding of a subject. A successful basic research project would result in the discovery of a new phenomenon or new ideas of general interest. This research undertaken for the purpose of the advancement of knowledge for knowledge's sake is primarily done by universities, through the public funding from governments (Roll-Hansen, 2009; Bentley *et al.*, 2015; Manning *et al.*, 2005).

In contrast to basic research applied research is defined as the research directed toward using the knowledge that is gained by basic research to create innovations that serve a practical or utilitarian purpose (Parker, 1984). Applied research focuses on solving a practical problem. As applied research has a defined goal that has to be accomplished, it can be used as an investment, as there is an expected return (Roll-Hansen, 2009; Bentley *et al.*, 2015; Manning *et al.*, 2005).

The other three phases shown in Figure 4.3 are the ascending, mature and descending phases of a technology. During these three phases, companies aim to generate the highest possible income. The business strategies that are in place guide a company's actions in the different phases of the technology. The technology developments includes delaying the inevitable end of the technology or product viability and work on the technology that will replace the current product (Park *et al.*, 2015).

The success of a new technology is determined by the efficiency of implementing the new technology into the market. By increasing the rate at which a technology is implemented into the market, the maturity phase of the technology can be extended. Companies can do this in various ways, but advertising is the most common method (Cetindamar *et al.*, 2010).

The maturity phase is where companies make the largest proportion of their money. The technology is known and works efficiently. At this point, the demand is higher than the supply, which allows the owner of the technology to set the price. This is also the time when competitors move in, to capitalise on the company's inability to meet the market's demand with their own version of the technology (Cetindamar *et al.*, 2010).

Finally, all technologies reach a point where it is no longer profitable to sell on the market. This can be for multiple reasons: market saturation, a new technology on the market or that the technology has become obsolete. All companies must accept that this will happen, and have to plan for how to proceed after the termination of the technology (Cetindamar *et al.*, 2010).

## 4.3 Intellectual Property Rights

The rate of technology development has increased exponentially throughout history. This can be seen in how the technology for long distance communication has improved over the length of humankind's existence. In fact, this is one area which has evolved to the next phase of the technology before the world had even fully adapted to the previous stage.

Until the invention of the telegraph in 1840, the only method of long distance communication was to send a physical object. It took less than 27 years to invent the telephone, 18 years to develop wireless radio communication and 75 years to create a platform in which to store electronic data from an off-site point. From there, it took 22 years to develop the World Wide Web, which allowed everyone who had access to an internet connection to share data. Finally, it took 15 years to get all that information into the palm of peoples' hands through mobile devices. This demonstrates the rapid improvement of technology in just the field of communications. There are numerous other examples of this including travel, writing, food production, power production, etc (Simonson *et al.*, 2013).

The second aspect that the communication example illustrates is how the sharing of knowledge changed in the last two centuries. In 200 years, people went from communicating by physically travelling to a place in order to convey a message, to finding out about a natural disaster on the other side of the globe in the very moment it occurs.

Finally, communication is an easy way to demonstrate how technology has changed intellectual property rights (IPRs). Patents, copyrights, and trademarks have existed long before human kind invented a way to communicate instantaneously. There are numerous examples of scientific figures in history who discovered something almost at the same time. This is often referred to as multiple discovery or simultaneous invention. In modern times scientists publish their research, and the whole world is instantaneously informed about it at the moment of publication. If a company releases a product, their competitors can take the product apart the moment it comes onto the market. They can then reverse engineer another company's products, and use it to improve their own.

These are all reasons why IPRs have gained so much importance in the last few decades, as knowledge spreads extremely quickly. Today's industries revolve around the knowledge they have access to, resulting in IPRs becoming essential in commercial entities. IPR held by competition can be an impediment to the development of a company's own technology.

As universities potentially deal with new innovative creations in any research projects undertaken, it is important to understand the options that are available for the protection of these innovations. Although the protection of Intelectual Property (IP) is important to universities, they have different motivations for protecting innovations, as their funding does not come purely from the sale of these innovations.

## 4.4 IPR Types

IPRs are used to offer protection for innovative creations. This includes a broad spectrum of artefacts, such as music, works of arts, written works, technological inventions, distinctive signs, etc. There are different protection methods for different innovative creations, and they generally fall into the following six IPRs, as described by Cetindamar *et al.* (2010) and illustrated in the example of the Plant Breeders' Rights Act 15 of 1976 of the The Republic of South Africa (1976). It must be noted that there are many differences between the IPR systems of different countries.

Creative innovation can be protected by one of the following IPRs:

1. Patent;
2. Plant breeders' Rights;
3. Copyright;
4. Trademark;
5. Domain Name;
6. Industrial Design;

Patents and plant breeders' rights will be summarised together as they provide similar protection for different types of inventions. The reason that the distinction is made is because of the ethical implication of owning the rights to a living organism. Some countries allow an applicant to register a patent on plants, but many countries are removing the ownership of patents on living organisms (Knight, 2001).

Patents, and in some industries, plant breeders' rights, form the back bone of many knowledge intensive companies. A patent protects a technology from being used by the owner competitors, and plant breeders' rights performs a similar function with respect to the development of plants. This allows companies to sell their innovations without fear of their products being infringed upon by their competitors.

Copyright is the IPR for creative and artistic work. This includes books, films, music, paintings, photographs, and software. Copyright gives an author complete control over the reproduction and adaptation of his/her art. Copyrights also constitute the only IPR that do not have to be registered.

Although software is protected by copyright, there are some countries, such as the United States of America (USA), where a patent can be filed on software. In the USA, patents can be used because they affirm that software plays a significant role in the industry and therefore acts as a normal, physical invention. In Europe, China, and Japan, the other major players in IPRs, the belief is that software evolves so quickly and drastically that it does not make sense to file a patent on a technology that is sure to become obsolete in two years' time. Therefore, these areas only use copyright and not patents to protect software. A trademark is the protection of a distinctive sign used to identify a business, or entity. Trademarks can become one of the most important assets of a company. The value of trademarks lies in the brand name that is built through years of service to its clients (Cetindamar *et al.*, 2010).

A domain name is a distinctive internet address designated to a firm/ business/ service/entity. Most businesses will have this form of protection on their websites. Industrial design rights protect the form of an industrial object's appearance, style, or design (Cetindamar *et al.*, 2010). These two forms of protecting IPR are rarely used at universities in terms of disseminating knowledge.

Appendix A – provide a further discussion of each of the IPRs and their individual properties and limitations. It was deemed appropriate to include these descriptions in the appendix to the study, since the workings of the IPR system are not critical to the main narrative of the study. It has nonetheless been included to provide additional information for the interested reader.

## 4.5 Exploiting IPR

Section 4.4 explains the intellectual property rights (IPR) that can be registered for different innovative creations. However, it is important to know what strategies to apply in order to effectively exploit IPR. These strategies will focus on new and innovative technologies, which are mostly focused on patents, plant breeder's rights and trade secrets. Copyright is used to protect computer programs, and the design of the final product is protected by industrial design rights. These strategies can, however, also be used in other applications, with other IPRs. Figure 4.5 provides a brief overview of the different forms of intellectual property rights. It also gives an overview of the length of time that these IPRs are valid, and how to choose a form of protection.

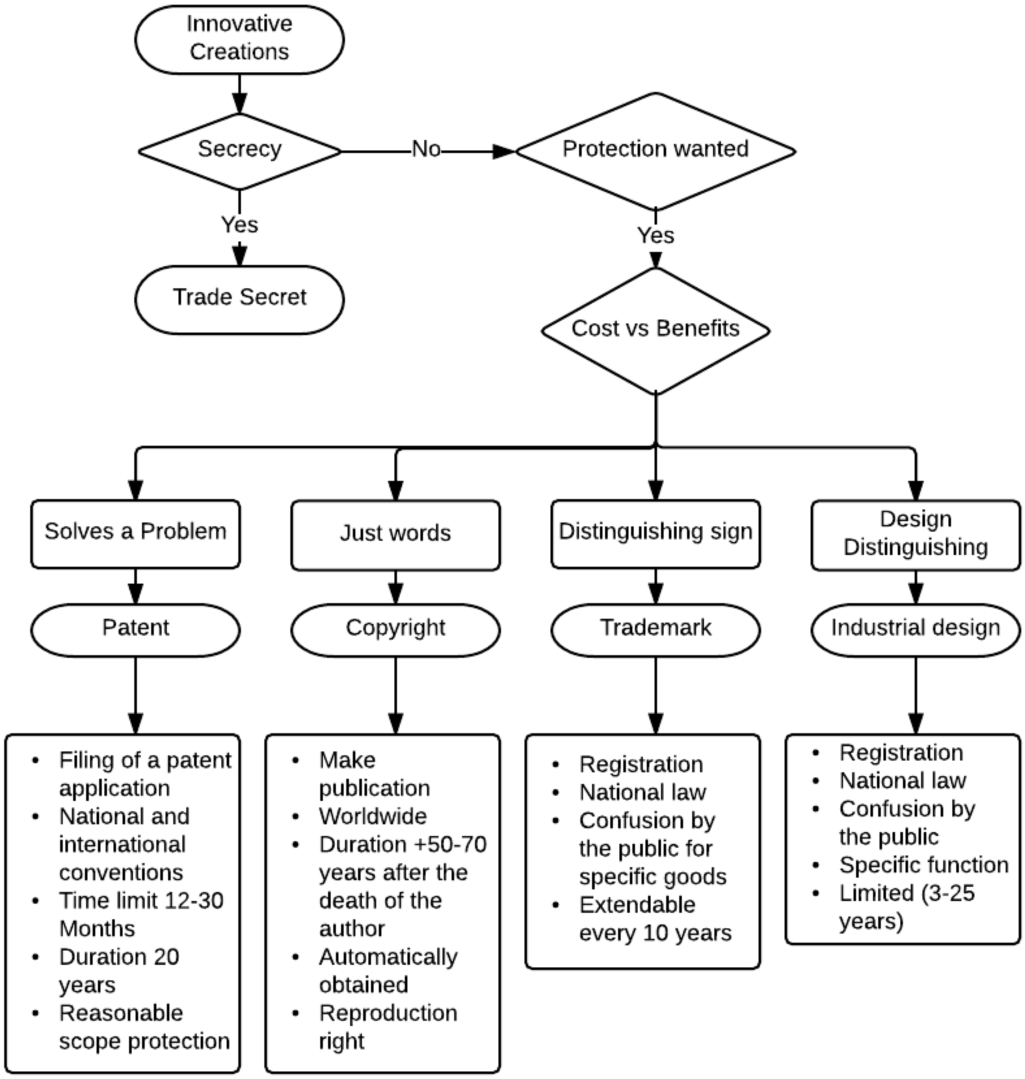


**Figure 4.5:** Innovation creativity (Cetindamar *et al.*, 2010; Brouwer, 2005)

When creating an IPR strategy for the company, the main goal should be to achieve Freedom-To-Operate (FTO). FTO is the ability to use, produce or sell a product or a process without causing infringement. Companies register and purchase patents to increase their own FTO, thereby limiting their competitor's FTO, or generate additional funds from licensing their technologies to increase the FTO of other companies. Patents are a good way to create FTO, because the idea is disclosed to the public, but the holder of the patent has exclusive rights to the patent (Cetindamar *et al.*, 2010).

Companies keep track of their FTO by building a patent portfolio. This portfolio not only include the patents that the company owns, but also those acquired through licensing, technologies that are trade secrets and technologies that are public knowledge. This portfolio will contain all the rights to use the creative innovations that are required to make the technology function (Cetindamar *et al.*, 2010; Brouwer, 2005).

New innovations can be sourced from multiple area entities, which includes internal development, collaboration, or external sources. Internal development is pursued by an internal R&D department, while collaborative development is achieved by collaborating with other companies or institutions. Purchasing from external developers can be done through buying the patent from the owner, taking out a license on the patent, or merging with or acquiring the company that holds the patent (Brouwer, 2005).

Licensing of patents is either exclusive, or non-exclusive. An exclusive patent will cost more, but the license will only be made available to one company. Exclusive licences are usually sold by research institutions or companies that have discovered a technology that is not relevant in their own business. A variation of the exclusive license, called a sole license, will exclude even the current owner from using the innovation. However, this is not a popular form of licensing.

A non-exclusive licence allows multiple companies to have access to the technology. These licences are substantially cheaper, but all the interested companies can have access to this technology. An exclusive licence focuses more on the generation of funds, while a non-exclusive licence focuses more on the dissemination of knowledge as more entities will have access to the technology (Cetindamar *et al.*, 2010; Brouwer, 2005).

Some inventors or companies sell their patents, but this is not done frequently. Patent holders prefer keeping the patent and giving an exclusive licence. If the licensee successfully commercialises the technology, the royalties from the licence will be substantial. If not, the license will be terminated, and the holder of the patent will obtain all of the development done on the technology. This increases the value of the technology for the new potential buyer of the exclusive licence. The patent will cost substantially more than a licence, since it will be a once-off payment for the technology. This may be considered if the technology forms part of the core business of a company (Cetindamar *et al.*, 2010; Brouwer, 2005; Knight, 2001; Shah *et al.*, 2013; Hsu, 1996).

Some industries, especially high-end technology industries, build up their FTO with cross-licensing. Owning all the patents required for some technologies is almost impossible, as too many are required. Cross-licensing agreements are made between firms, allowing them access to some of the patents owned by other companies. These agreements usually begin with long negotiations, because each patent has to be valued. The difference in the value of the patents shared will then be paid to the company whose collective patents have the higher value. These cross-licensing deals give companies FTO in these specific technology fields, but companies usually try to develop technologies to replace those gained in cross-licensing deals. This is to decrease their dependence on their competitors, as well as increase their bargaining power when negotiating a new cross-licensing deal (Cetindamar *et al.*, 2010).

Patent pools is a form of cross-licensing that involves multiple technologies and multiple companies. A patent pool occurs when multiple companies pool their patents together. Any potential licensee will then negotiate with the pool to produce the technology. The pool is either run by one of the partner companies, an independent company or a company founded for the specific goal of running the pool (Cetindamar *et al.*, 2010).

Patent pools are useful for technologies that will not function without patents from other companies. An example of this is provided by Prasad *et al.* (2006) and den Uijl *et al.* (2013) in an examination of Blu-ray technology. Blu-ray technology is not only for Blu-ray disks, but also everything that is required to read the disk. The technology required to produce this Blu-ray technology is owned by more than 20 companies, including Disney, Philips, Sony, Samsung, etc. These companies formed a patent pool, and founded a new company to manage the licences from this pool, called One-Blue.

The royalties are divided between the patent holders of the pool to the value of the patents that they hold respectively. The people holding the patents in the pool also have to pay royalties, but they are partially refunded. Figure 4.6 shows that the number of licences issued decreases substantially with a patent pool. Considering that every licence issued requires negotiating and contract agreements, which generates legal expenses, it becomes cost effective to form a patent pool in these technologies that require a substantial amount of patents. It is even more clear when one considers the Blu-ray patent pool and the administration cost involved if a patent pool had not been formed (Cetindamar *et al.*, 2010).

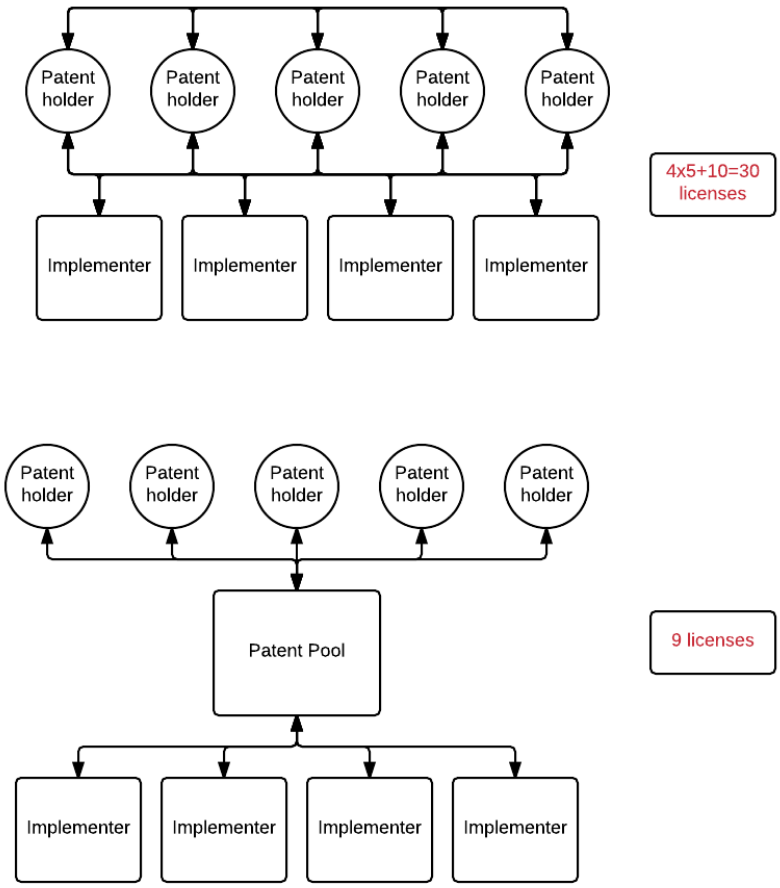


**Figure 4.6:** An Example of a patent pool *adapted from* Prasad *et al.* (2006) and den Uijl *et al.* (2013)

## 4.6 IPR of Commercial Entities

In the case of an industrial innovation, a company has three options for protecting its innovation: (1) trade secrets, (2) publish the invention or (3) register a patent. All three methods are important to the industry, and they are all subject to certain advantages and disadvantages. Since filing and maintaining a patent can be expensive, patenting all inventions made by a company is not always practical, while attempting to keep all the company's inventions as trade secrets can be disastrous.

Sometimes patenting is not the best option for protecting technologies. Some companies publish their inventions in journals. The reason for this is that patents are expensive to obtain and even more expensive to maintain, whereas publications are relatively free of charge. As companies develop technologies, they discover multiple incremental inventions that improve their products and processes. These inventions are beneficial, but are hardly worth the costs of a patent. They are also not worth the additional costs and security measures needed to make them trade secrets, since there is always a risk of a competitor company acquiring the technology and patenting it. Companies will then opt to publish the results in a paper, allowing that invention to become common knowledge, ensuring that others cannot patent the invention. The main goal is to create FTO for the company, and not to necessarily withhold it from other companies (Lotka, 1926; Merton, 1957).

Trade secrets are not as effective as people believe them to be in most companies (not considering drastic measures, such as corporate espionage). There are many simple examples of how knowledge can be leaked to the competition. The most obvious of these is that employees talk without any malicious intent. Although they have all signed confidentiality agreements, news still gets out in conversation. Trade secrets, in industries, are usually used to protect small inventions that slightly improve the product or process. The sum of these small inventions and how they interact lends trade secrets their power.

Finally, there is the registering of a patent. The patent prevents others from using it, but in return it has to be disclosed to the public. Patents are discussed in detail in Appendix A.1. It should be noted, however, that patents are the surest form of protection, but only last for 20 years. Also, the longer it is protected, the more expensive it becomes due to the maintenance fees (Knight, 2001; Shah *et al.*, 2013; Hsu, 1996).

Section 5.1 will discuss that the largest cost in R&D lies in the payment of salaries. Moving development of technologies to developing countries, where the cost of living and salaries is lower than in developed countries, is one way of reducing R&D costs. Developing nations are usually classified as having weaker IPR protection. The reduction in cost of developing in these weaker IPR countries is a big opportunity that is seldom disregarded. Strategies have been developed by companies to manage their technology development in these countries with weaker IPR protection (Czarnitzki and Kraft, 2012).

To make these choices, it is important for companies to distinguish between its core and non-core activities. IPR protection is not as important to the non-core activities, as long as the countries in which they are developed have low costs, and the employees have the technical and scientific skills to work on the development projects. Understanding which activities could be developed at cheaper costs is extremely important to a company (Czarnitzki and Kraft, 2012).

These companies generally take strong precautions in order to limit knowledge spillover in these developing countries, which are generally countries with weaker IPR protection. They firstly document and secure their trade secretes. These trade secrets, are rarely shared with the employees working in these developing nations, and those that are, will be protected by contracts. Companies spend time educating employees on IPR and the various ways in which they work in different countries. This enables employees to understand what is acceptable behaviour and what is not. Companies also develop good relationship with the relevant governments. This is mainly because in the event of a court case, the government will at least give them equal footing in the case. There are numerous cases in the world where governments in these countries with weaker IPR protection refused to support the foreign company's claim, and invalidated the patent. Lastly, companies hire local IPR experts, especially lawyers, to help them reduce the risks of losing business to competitors who would infringe upon the product, consequently invalidating their patents (Knight, 2001).

As mentioned in Section 4.5, patents give companies FTO, which renders the commerce sector the main applicant for patents. Since all patents deal with industrial inventions, active patents are generally found in use in industry. Current patent laws protect the inventor so that companies cannot use an invention without permission from the owner of the patent. These laws, however, have opened doors for Non-Practising Entities (NPEs) or for what is more commonly known as "patent sharks" or "patent trolls". The formal definition for an NPE is a company that has acquired intellectual property assets (patents) solely for the purpose of extracting payments from alleged infringing actions. NPEs do not do research or develop any technology or products related to their patents. They behave opportunistically by waiting until industry participants have made irreversible investments before asserting their claims. Figure 4.7 shows how the number of NPE lawsuits per year has increased, but there does not seem to be an obvious solution to the problem. The only law that will stop this is one that prevents lawsuit action by companies who do not have any production on the patent. However, this will remove all private inventors from the industry (Knight, 2001).

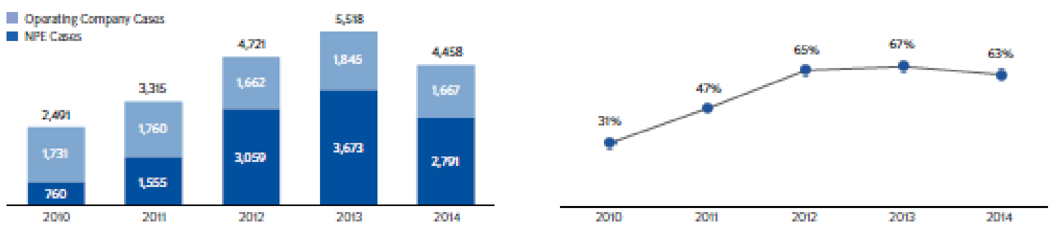


**Figure 4.7:** Lawsuits involving non-practising entities per annum (RPX Corporation)

## 4.7 Collaborations

Collaboration forms an important part of the R&D processes. Collaboration between companies allows these companies to draw on the experience and funds of all the companies involved at the cost of sharing the rewards between all those involved in the collaboration. The cost versus reward calculation will have to be done for every collaboration opportunity, as this will be dependent on numerous factors, including the type partners, whether the research will be on its core business and the rewards of the collaboration. In collaborations, there will always be the risk of the partners consuming each other's market (Czarnitzki *et al.*, 2015).

Selection of partners to collaborate with is crucial as it can increase or reduce the risks. Collaborations are therefore divided into two kinds: vertical and horizontal collaborations. The most successful collaborations are between a company and its suppliers or customers, which is referred to as vertical collaboration. These collaborations usually result in an increase in market share of all the parties involved, without consuming their partners' market shares. This allows the company to receive from or supply to a more productive company, as they themselves are also more productive. Neither company will capture the other's market share, as they do not have the same market (Czarnitzki *et al.*, 2015; Belderbos *et al.*, 2014).

Horizontal collaboration is a research endeavour pursued by competing companies. There are some cases where this collaboration was to the benefit of all involved, but there are numerous cases where the research led to the ruin of one or more partners. There will always be the risk of one company capturing some of the other company's market with this type of research. Also, before the collaboration project is started, agreements have to be reached concerning the IPRs that each of the partners holds that is needed for the project. This sharing of information increases spillovers to all the partners, reducing any competitive edge that the companies would have had before the collaboration (Czarnitzki *et al.*, 2015; Belderbos *et al.*, 2014).

Companies also use contracts to coordinate and control their partners. These contracts usually include the details of the deal, the possibilities of monitoring the partner's progress and penalties for late deliveries. Other very important parts of the contract are the arrangements made in the background - the IP that is required to develop the new technology, and foreground IP - the IP that is generated from the project. All these technologies are agreed on before the collaboration begins (Czarnitzki *et al.*, 2015).

Companies will sometimes agree on co-ownership of the IP that is created from a collaborative R&D project, but this produces numerous problems.

When both partners own the IP, both can rightfully and legally sell the rights to use it. This implies that there is nothing stopping a company's research partner from selling the product to their competitors. This might be done to remove the partner from the market, but it can also be done if it is merged with an outside company, or is bought out by another company. Laws also differ in different countries. For instance, in the European Union, a co-patent cannot be licensed out unless it is agreed upon by both parties. In the United States of America, in contrast, a co-patent can be licensed out without the approval of the other partner (Belderbos *et al.*, 2014).

It is agreed upon beforehand which IP will be owned by each party when the project is completed. The company who invested the most in the project will own the IP, and the other partner will own either an exclusive or non-exclusive licence - depending on the agreement that was made before the project began. This investment can be the capital contributed to the project, but it can also be the IPR on which it was built (Belderbos *et al.*, 2014).

## 4.8 Chapter Summary

This chapter provides a discussion of the knowledge that is to be disseminated to industry from the university. Although, this chapter takes a more industrial focus, the principles that are discussed here are applicable to both the industrial and academia sectors. Knowledge that is transferred to industry will always be technology in some form or another. Universities will, however, rarely participate in a technology's life-cycle after the research and development phase. It is mostly the industrial and commercial sector that exploit the other phases of the life cycle of a technology. Although research is a university's primary focus, there is more than one type of research that can be conducted at a university. This why it is important to draw a distinction between basic and applied research and understand its function in a university.

The chapter then continues to discuss the different types of IPR that are available for the protection of creative innovations. Although this chapter only gives a summary of IPR, a complete literature study is provided in Appendix A. It is important to note the limitations that are on the different types of protections, as this would determine their use and focus in a university setting.

The chapter also discussed the exploitation of these IPR, starting first with the general systems that are used to ensure that the most is made from the IPR. The study then continues to discuss the IPR in commercial entities. Commercial entities and universities see IPR and R&D completely different.

Commercial entities want to keep all their innovations a secret for as long as possible, and where they have no choice they would patent a technology in a way that would benefit their own business and limit their competitors. Universities what to disseminate their knowledge, as failing to do so would result in a technology that does not contribute to the mission of the university.

Collaborations are discussed to show the benefits that are available to all parties concerned, but also the risks involved. Also, as universities do not compete in the commercial industry, they can form very advantages relationships for all parties concerned, as they will be part of a horizontal collaboration.

# Chapter 5

# Literature Review of the Country-Specific Factors Influencing Knowledge Dissemination

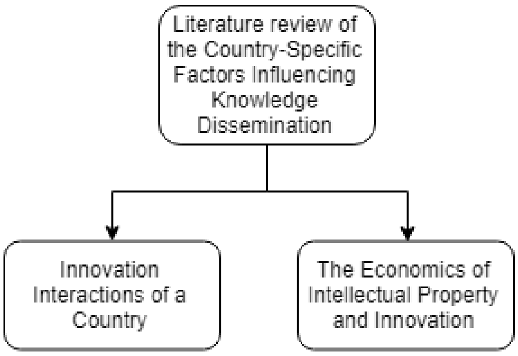


**Figure 5.1:** Overview of Chapter 5

The purpose of this chapter is to identify the factors that influence the utilisation of IPR in a country. It will aim to identify elements of a country that increase and decrease knowledge dissemination. This chapter is not limited to universities and public research institutions, as the theory discussed in this chapter is mostly focused on commercial entities.

- Section 5.1 – Innovation Interactions of a Country: This section aims to identify the three major entities that drive innovation in the country, and the interactions between them. These entities are the government, industry and universities.

- Section 5.1 – The Economics of Intellectual Property and Innovation: This section covers the economics of innovation, focusing on the fact that innovation is driven by incentives.

The aim of this chapter is to identify the important concepts that define the context of a country, insofar as its influences the knowledge dissemination in that country. This chapter will look at how the interactions between governments, industry and universities influence the generation of innovation in a country (Section 5.1). The interactions of these entities and their influences on one another are described in both push and pull models of innovation.

Following these models, the chapter discusses the economics of intellectual property and innovation (Section 5.1). This section will not only focus on stating the influence that innovation and intellectual property have on an economy, but also the incentives that are created to increase the innovation from entities, acting as a driving force for innovation in a country. Innovation always results in higher social returns than private returns, resulting in governments aiming to increase innovative outputs.

Developing, emerging and developed countries are the three categories of countries as are defined by the United Nations in the World Economic Situation and Prospects(WESP) report (Zhehmin *et al.*, 2018). The study focuses primarily on developing and developed nations, as emerging countries only comprise 9% of the total countries. They are also primarily located around eastern Europe and Western Asia. All the countries in Africa are categorised as developing countries, as was found in the report of the United Nations (United Nations, 2014).

These countries are categorised into the mentioned groups on the basis of numerous indices, including Gross Domestic Profit (GDP) per capita, purchase power of the currency and the availability of skilled labour. Developed countries are characterised as countries with high GDP per capita strong currency and a good availability of highly skilled. As these countries have more money, they generally have a lower unemployment rate and the majority of their economies are driven from urban settings (Chee *et al.*, 2016; Niebel, 2018).

Developing countries are generally poor countries, with a high unemployment rate and low number of skilled labour. These countries have economies that are generally more focused on rural areas, and producing and exporting goods that are very labour intensive, such as mining and agriculture (Chee *et al.*, 2016; Niebel, 2018).

Through a combination of interactions, there are three sectors that drive innovation in a country. These entities are the government, industries and universities. Each of these sectors has thier own goals and aspirations regarding innovation. Nonetheless, collaboration between these entities can be beneficial for all entities involved (Van Looy *et al.*, 2004; Etzkowitz and Leydesdorff, 2000; Etzkowitz *et al.*, 2000).

A country's government has a different role to play in the country's innovation when compared to the role of industry and higher education. Although governments also innovate their own processes, the government's main focus, with regards to innovation, will be to increase the social benefits of innovation in the economy. This will be elaborated on in Section 5.1, but essentially governments aims to increase the standard of living of their citizens. Governments do this in numerous ways, including the protection of innovations in exchange for disclosure (intellectual property rights) and subsidies for research in both the industrial and educational sector (Etzkowitz and Leydesdorff, 2000; Owen-Smith and Powell, 2001; Van Looy *et al.*, 2004).

Innovation that emerge in industry are there to solve specific problems, whether these problems relate to the increase of production, the creation of a new product to satisfy the market, or to improve the efficiency of delivery to the clients. Innovation is supposed to be a continuous process in industry, as there should be a constant creation of value. This is possible as industries generate profits through the selling of goods or services (Knight, 2001).

Universities focus mostly on teaching and research which reduces their ability to commercially enter the market. Universities therefore have a greater focus on selling the research, that when developed into technologies industry or government (Baya *et al.*, 2011; Lane, 1999). This is discussed further in Chapter 6.

Universities have two methods of selling the research that is produced at the university. The first involves the university selling research which was not specifically requested by industry. This is referred to a technology push. In this case, a university would identify a gap in the market, or a short coming in the technology of the industry (Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2000; Rosenberg and Nelson, 1994; Feinson, 2003)..

In these cases it would be better for universities to work in collaboration with potential customers from the beginning as this could increase the success of the sale. Doing research with continuous feedback from potential customers will result in the final research costing less than moving forward alone (Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2000; Rosenberg and Nelson, 1994; Feinson, 2003)..

The second method is when a university is commissioned to work on a particular problem for industry. This is referred to as technology pull, as industries directly dictate the research done at the university. This results in funding for research at a university, and a less expensive option to do research as a company (Lundvall, 2005; Edquist, 2001; Feinson, 2003).

## 5.1 The Economics of Intellectual Property and Innovation

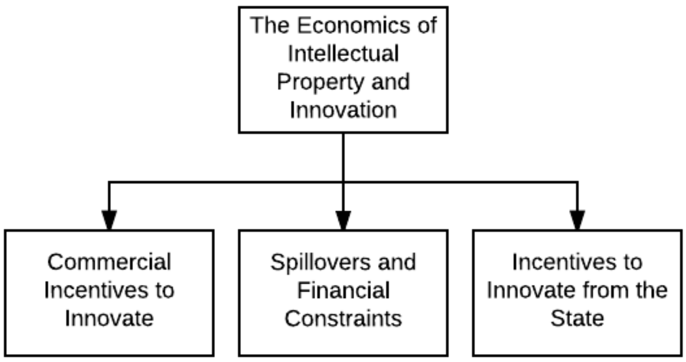


**Figure 5.2:** Overview of the economics of intellectual property and innovation

The first theory and model which linked innovation to the economy of a country was presented by Joseph Schumpeter. He defined innovation in a broad sense, declaring that it is "doing things differently". The types of innovation included introducing new commodities, new ways of producing old commodities, opening up new markets for new products, new sources of supply or materials, and reorganising an industry (Gilbert, 2006).

Gilbert (2006) makes the distinction between invention and innovation, as well as between an inventor and an entrepreneur. Invention always involves a scientific novelty and an inventor is the person who produces this idea. An inventor can create an invention and not generate any value from it. Innovation is concerned with the creation of value and an entrepreneur is someone who gets things done and it does not matter whether an old or a new idea is used to solve the problem .

Schumpeter had two main hypotheses, one on each side of the spectrum. There is proof that supports both hypotheses to this day.

Schumpeter's first hypothesis to be developed, is sometimes called Schumpeter's hypothesis of creative destruction. The hypothesis is that the typical industrial entrepreneur of the $19^{th}$ century was perhaps the man who put into practice a novel method of production by embodying it in a new firm and who then settled down into a position of owner-manager of a company, if he was successful, or of stock holding president of a company, getting old and conservative in the process (Gilbert, 2006).

The hypothesis simply stated, implies that new small firms carry innovation as they are more flexible and can respond to the market quickly. As the company becomes more successful, it grows, closing down the large, inflexible companies, but becoming one of the large, old and inflexible companies in the process. A new, small innovative company would start up and the process would start again from the beginning (Gilbert, 2006).

Twenty years later, Schumpeter wrote his second hypothesis. It simply states that most of the cheap and simple inventions have been made. Not only is development now sophisticated and costly but it must be on sufficient scale so that successes and failures will in some measure average out. Few can afford it if they must expect all projects to pay off (Gilbert, 2006).

Schumpeter's hypothesis was based on the market failures of companies that are involved in innovation. These three market failures are externalities, indivisibilities and uncertainty. Schumpeter argued that large firms have more capital to invest in R&D. This allows them to spread the R&D fixed costs over a larger sales base, so they can exploit the economies of scale and scope in R&D and can more easily exploit an unexpected discovery. Large companies can also spread the risks involved in R&D by undertaking many projects simultaneously, easily obtain financing for R&D and be able to hire more highly skilled people (Gilbert, 2006).

Schumpeter's ideas are still debated today. In his theories, one aspect was made clear, namely that an incentive is needed to motivate innovation. Incentives are most frequently expected profits from investments, but there are other incentives, such as subsidies from the government (discussed in Section 5.1.2) that are available to companies to increase innovation.

Investing in innovation has some major drawbacks, and these have to be taken into account when constructing models for investment in innovation. Unlike investment in assets, investments in new innovations that fail can hardly ever be recuperated. R&D is usually characterised by wasted capital, as the largest costs involved in R&D are wages. R&D is also subject to a great deal of uncertainty, which is to be considered when dealing with innovation, as it makes investments risky.

A capital investment in a company to acquire a new asset or improve an existing asset come from either an external or internal source. Internal sources are from the available capital of the the company that are allocated. External sources are loans or investments from external entities. Internal investment does not cost the company interest the company already has the money. External funds, however, always comes at a cost to the company something, mostly in the form of interest.

Uncertainty that is present in all new innovations limits the availability of funding because the only source of funding is internal funding. External funding is too expensive, as it will be an investment in a project with a high risk of failure and, therefore, high risk of generating no return on the investment (Belleflamme and Peitz, 2010).

Innovation can be divided into two categories, product innovation and process innovation. Product innovation is the generation, introduction and diffusion of a new product, whereas process innovation is the generation, introduction and diffusion of a new production process. Belleflamme and Peitz (2010), stated that product innovation is just an extreme case of a process innovation, as they assume that a new product is released because it was cheaper to manufacture, yet still delivers the same, or even a better, performance. As most basic theories on innovation mainly focus on process innovation this assumption will include all aspects of innovation.

Making this assumption still excludes a large portion of product innovations, specifically those products that are completely new to the market. These innovations are almost impossible to predict as they are subject to numerous other uncertainties that are not included in process innovations. For example, in the case of a new product innovation, there is no accurate way to know whether the market is actually in need of this product. In contrast, a process innovation only increases the efficiency of the current processes to produce a product that already has a market. Some of the primary goals of a process innovation includes decreasing the cost, increasing the production rate and increasing quality. Companies are also still able to generate profits in a competitive market structure by differentiating products. Inserting new products in the market allows the monopolist to price discriminate (Tirole, 1988).

The following subsections discusses the economic impact of innovation, starting with the economic incentives that are involved when creating an innovation in Section 5.1.1. Section 5.1.2 continues by explaining the impact of restriction of funding on innovation and the importance of internal funding versus external funding. Finally, Section 5.1.3 aims to identify the reasons why governments provide subsidies to research and development projects, and the importance of selecting the correct projects to fund.

### 5.1.1 Commercial Incentives to Innovate

There are numerous economic models which try to emulate the impact of innovation on a company. Some of the models are explained in detail in Appendix B. All these models are centred around the monetary gains that a company can achieve when innovating. A summary of the models are:

1. In the case that the impact of the innovation that is invested in is known, companies in competitive markets will show greater investment in innovation. A real-world example of this situation is the auctioning of an exclusive license. (Arrow Model)

2. In contrast, when the innovation that is invested in and the impact of it is unknown, a monopolist will show greater investment in the innovation than a competitive company when a company is threatening the monopolist's position. (Gilbert/Newbery Model)

3. Furthermore, when there is uncertainty about the final outcome that possibly puts the company in a monopolist position, a challenger will be willing to invest more than a monopolist or a competitive company. (Patent Race Model)

### 5.1.2 Spillovers and Financial Constraints

Two of the main market failures in innovation entails the inherent nature of innovation and R&D. The first requires knowledge to be spilled over to the public. The second necessitates financial constraints involved in investing in innovation.

The social benefits that are derived from innovation are mostly dependent on spillovers. All intellectual property rights, such as patents, are an agreement between the government and the owner of the IPR, that the government will provide protection of the creation to the owner in exchange for disclosing the details of the IPR to the public (Czarnitzki and Kraft, 2012).

The social benefits that come from spillovers are mainly associated with uplifting the entire industry. If one company produces a new innovation, other companies will either formulate new ideas on how to solve their own related problems, or generate new ideas based on learning what is possible and what can be achieved. Spillovers also improve the situation for customers, as prices decrease and product choices increase. These spillovers will decrease private pay-off profits, but will increase social benefits (Czarnitzki and Kraft, 2012).

A study conducted by Mansfield (1985) asserted that spillovers occur more rapidly than suspected, even in highly innovative industries. Mansfield (1985) stated that it takes 12-18 months for information on R&D decisions, and no longer than 12 months for information on new products to be leaked from the company. He accredited this to patents, publication, reverse engineering, informal contacts, common suppliers and common customers (Czarnitzki and Kraft, 2012).

These spillovers result in loss of profits, becoming one reason for the under-investment in innovation. There are some methods to reduce competitors from exploiting an invention without payment, such as patents. However, Arrow (1962) stated, no amount of legal protection can make a thoroughly appropriate commodity of something so intangible as information (Czarnitzki and Kraft, 2012).

Financial constraints also plays a substantial role in innovation. The capital required to invest in innovation usually comes from internal funds, as external funds are expensive (due to the uncertainty involved with innovation). Figure 5.3 shows the difference between an unconstrained company, (A), and a constrained company, (B). In the case of company A, it has the funds to invest in innovation to its full capacity. Company B, on the other hand, is constrained. Therefore external capital needs to be obtained in order to reach the maximum capacity of innovation. As external capacity comes at a cost, the potential R&D that the company could have accomplished is reduced.

Delta C exhibits how additional internal funding could change the potential investment in innovation. In the case of Company A, additional funding would not have increased the innovation created by the company. However, in the case of company B, additional funding can help it reach its innovation capacity.

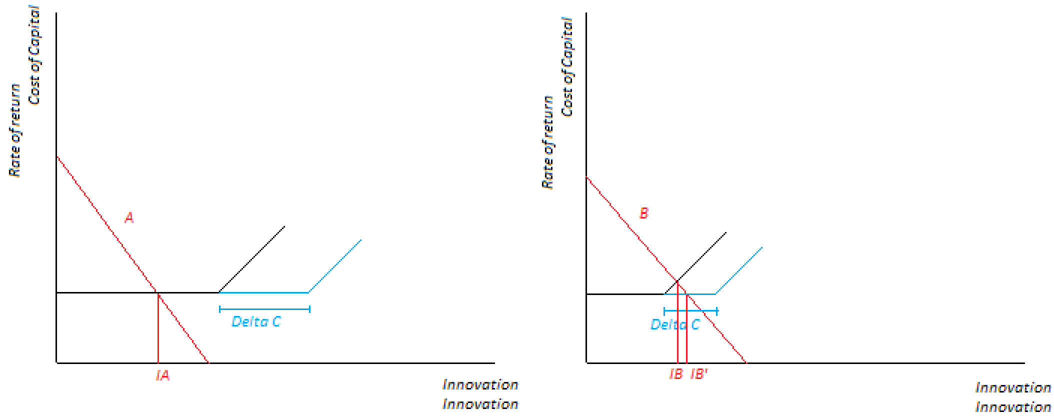


**Figure 5.3:** Financial Constraints

Financial constraints are not only dependent on available capital, but are also dependent on the innovation capacity of the company. Czarnitzki and Hottenrott (2010) state that companies with low internal funds, and high innovation capacities are the most likely to be constrained. This is very evident in small and young firms that are operating in industries that are knowledge intensive.

Table 5.1 and Table 5.2 reveal the different types of research. Czarnitzki and Hottenrott (2010) mention that cutting edge R&D will always be constrained, as seen in Table 5.1, because of the characteristics of this type of research. This financial constraint results in slower technology processes, especially in the case of radical innovations. Cutting edge R&D is the driving force behind technological development, and thus cannot be ignored. Cutting edge R&D yields the highest social return, albeit negatively for a company and positively for society.

Czarnitzki and Hottenrott (2010) also stated the ‘R’esearch is more constrained than ‘D’evelopment. This is represented in Table 5.2. Public research institutions, such as universities play such a crucial role in the economy, because their focus is on ’R’esearch amd the dissemination thereof. Universities remove a lot of the risks for companies by focusing on research and allowing companies to work on development of the technologies.

Financial constraints can lead to a cycle in which innovation continues to decrease. Financial constraints will lead to sub-optimal innovation performance, which in turn leads to a competitive disadvantage, which then leads to sub-optimal financial performance, ultimately resulting in further financial constraints. This cycle is difficult to combat, since the only way to increase profits is to reduce financial constraints. Acquiring external finances is expen-

**Table 5.1:** Heterogeneity of R&D (*adapted from* Czarnitzki and Hottenrott (2010))

| Routine R&D | Cutting edge R&D |
|---|---|
| Imitation or variation | Radical innovations |
| Strengthen product lines | Market novelties |
| Only new to product portfolio but not new to the market | Involves basic research |
| Lower resource requirements | Resource intensive |
| Returns sooner and more predictable | Highly uncertain in terms of default and expected returns |
| Lower default risk | Secrecy issues |
| Returns from initial product as source for financing | |

**Table 5.2:** Research versus development (*adapted from* Czarnitzki and Hottenrott (2010))

| 'R'esearch | 'D'evelopment |
|---|---|
| Uncertainty of project outcome | Based on the previous success in 'R'esearch |
| Higher probability of no returns at all | Higher probability of returns |
| Far from the market | Patentable results |
| Knowledge creation | Closer to market |
| Usually no tangible assets | Yielding returns sooner |

sive, and as such it does not increase the innovation possibilities by much - as shown in Figure 5.3

### 5.1.3 Incentives to Innovate from the State

State-driven incentives are essentially a motivation for companies to increase knowledge production and to innovate. Incentives are mostly used to reduce financial constraints, enabling companies to fulfil a greater portion of their innovative capacity, and thereby increasing the social returns from innovations. When companies are given incentives to innovate, it is important that the companies do not only innovate according to the privately efficient production of knowledge, thereby reducing the dissemination of knowledge throughout society. New knowledge that is produced does not have a social benefit if it does not reach the public. Therefore, incentives should also encourage efficient knowledge diffusion by increasing knowledge spillovers (David *et al.*, 2000; D'Aspremont and Jacquemin, 1988; Takalo, 2013).

Figure 5.4 shows the Private Marginal Rate of Return (MRRp), the return on an investment that a company is expecting from an innovation. The optimal point for innovation is located where the cost of R&D (MCC) crosses the marginal rate of returns. However, in this hypothetical case, the Social Marginal Rate of Return (MRRs) would reach its optimal point at a higher cost, since the social rate of return is always higher than the private rate of return. The grey coloured triangle indicates the welfare loss when companies only innovate to the competitive level of R&D (Takalo, 2013).

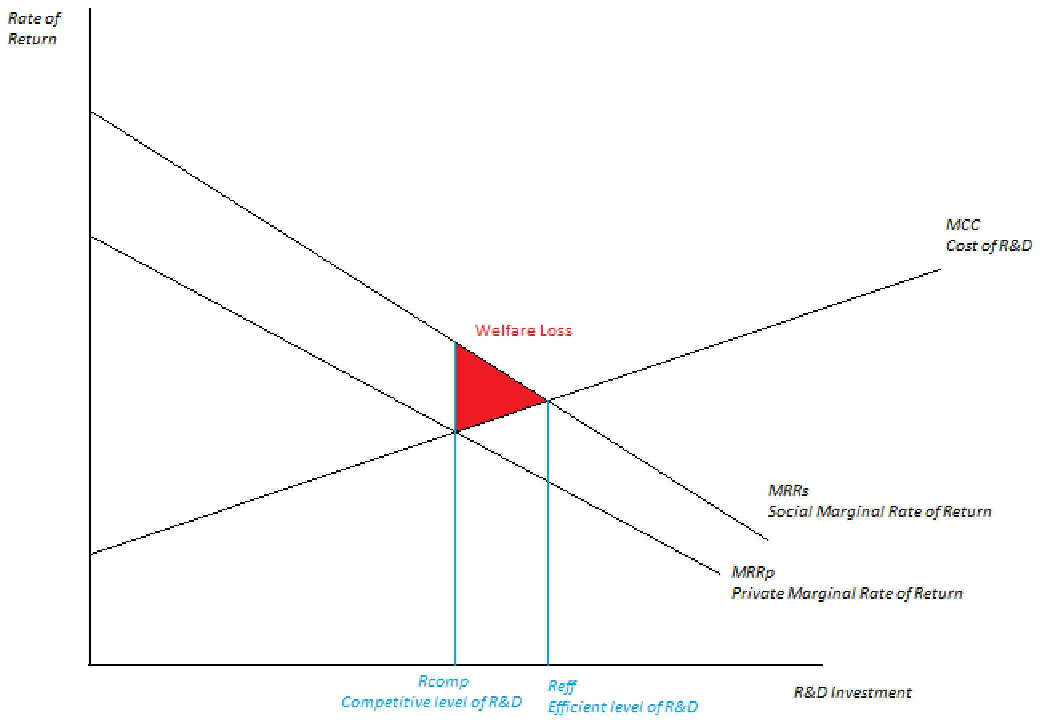


**Figure 5.4:** Competitive versus efficient R&D

Governments have developed various methods of creating incentives to encourage companies to innovate. Some of the incentives are purely capital orientated, but there are a number of other strategies to encourage innovation that do not involve the use of capital. The following strategies are some methods of the ways that governments apply as incentives to encourage innovation (David *et al.*, 2000; D'Aspremont and Jacquemin, 1988; Takalo, 2013):

1. Intellectual property rights;
2. Direct R&D subsidies;
3. Tax relief to reduce the cost of R&D;

4. Anti-trust exemptions for R&D collaboration;
5. Public production and procurement; and
6. Loans with low interest rates for financially constrained firms.

Subsidies are direct payments from government, and the outcome of this can be directly associated with the subsidies given. It is important to note the goals that subsidies should attempt to achieve. Subsidies are financial support that reduces the costs incurred through an R&D project, reduce financial constraints and increases company's incentives to engage in R&D activities without reducing knowledge diffusion.

With reference to Figure 5.3, subsidies should aim to increase a company's internal funds so that the financial constraint is reduced or even completely removed. Subsidies should also aim to increase the social marginal rate of return to the point where the optimum social rate of return is reached (David *et al.*, 2000; D'Aspremont and Jacquemin, 1988; Takalo, 2013).

Subsidy systems can also be problematic. The projects to which subsidies are allocated to have to be selected, and this selection process is important because not all projects undertaken in the country can receive a subsidy. These selections are usually made on the basis of which project is likely to be of the "highest benefit for society". State employees are, unfortunately, not all qualified to make these decisions, as they lack a working knowledge of the various industries. It is important to note that governments are generally short lived, but the consequences of governments are not (David *et al.*, 2000; D'Aspremont and Jacquemin, 1988; Takalo, 2013).

The second major problem with subsidies is that they are costly to society. Subsidies are generated from tax money could be used elsewhere, but it is used to encourage an increase in innovation. There is also a risk of companies exploiting subsidies, most notably in the case where subsidies are used for research that would have been done in the absence of the subsidy (David *et al.*, 2000; D'Aspremont and Jacquemin, 1988; Takalo, 2013).

## 5.2 Chapter Summary

In the previous chapter, the protection of creative innovations was discussed. This chapter focuses on "why" companies would create innovations. This chapter aims to provide an understanding of the function of innovation in a country, identifying the entities that benefit from innovations and finally, create incentives to innovate.

In summary, there are three sectors in a country that are of concern in driving innovation, namely, (1) Industry, (2) Government and (3) Universities. Industries innovate to generate capital, governments innovate as they have an obligation to increase the standard of living of the people in the country and innovation at a university is part of their core missions. Each of these sectors can work in isolation, but innovation in a country become more effective if there is effective collaboration taking place between these three entities.

Industries generally have the most incentive to implement innovations into a country, as their benefits are monetary. There are two theories that consider whether large stable companies or small flexible companies drive innovation from an industry point of view. This relationship between the small and large industries are important to note for this study, as this symbolises the universities' spin-off companies entering the industrial sector.

The chapter continues to describe what incentives there are to innovate. Although this is primarily focused on industry, it has a major impact on innovation generated at a university. In a small degree, these incentives are also extended to the university, but to a larger degree, when a university is marketing innovation to industry, it must focus on meeting these incentives. Innovation has different effects on industry, based on the nature of the market share. Incentives in a competitive market will differ significantly to company as a monopolist or a new company that is entering the market.

One of the main concerns with innovation in a company is spill-over effects. An innovation that has been implemented will always "spill-over" to competitors. Actions can be taken to reduce spill-overs, but it still does occur. Therefore, actions are taken to protect valuable innovations through patents, plant breeder's rights etc. Spill-over effects, however, are the largest contribution to the social benefits that are associated to innovation, which is the reason governments encourage spill-overs, such setting disclosure to the public as a condition of patenting an innovation.

Funding for innovation is expensive as most capital is invested in the salaries of the research teams. This translates to a company receiving most of the funding from internal sources. This point is important for spin-off companies, as they are based on new innovated ideas and require funding. University's investment in these companies are important, as they can find the companies from internal funds

Finally, governments create incentives for companies to innovate, mostly through monetary investment. In theory, there is always more social return than private return, and governments must aim to increase the social returns past the competitive level of R&D and up to the effective level of R&D.

# Chapter 6

# Literature Review of the Elements Governing Knowledge Dissemination at Universities

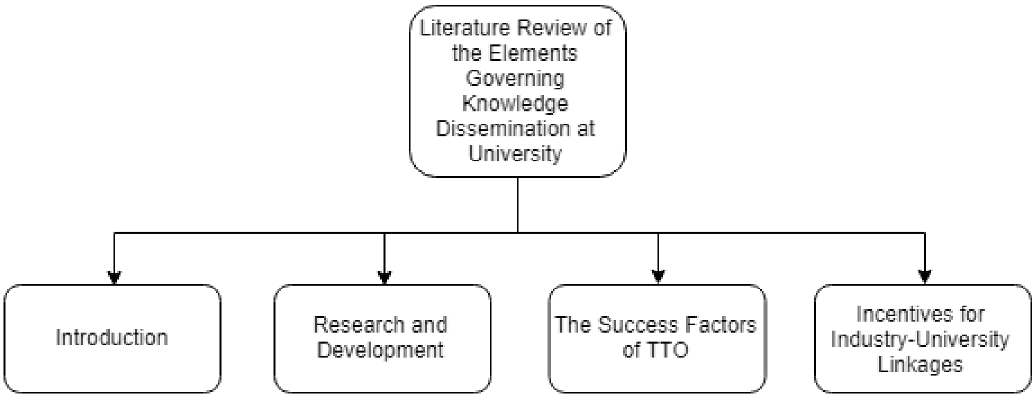


**Figure 6.1:** Overview of Chapter 6

The chapter will explain the different types of research and development that takes place, and how the different types are used and exploited.

- Section 6.1 – Introduction: This section aims to introduce the purpose of the chapter in terms of the overall project.
- Section 6.2 – Research and Development: Any research process evolves through different stages before it can be commercialised, and the aim of this section is to identify these stages and the contributions that a university makes toward research and development.

- Section 6.3 – The Success Factors of Technology Transfer Offices (TTO): This section identifies certain success factors for technology transfer from universities. These success factors have been identified from surveying the existing literature on the subject.
- Section 6.4 – Incentives for Industry-University Linkages: This section identifies the different elements of university and industry collaboration.

## 6.1 Introduction

Universities are one of the primary entities contributing to innovation in a country, with the others being the government and industrial sectors. Public universities, which are the focus of this study, receive the largest percentage of their funding from their government. As was stated in Section 5.1, governments aim to increase social benefits, which is then also dictated as a requirement to the universities.

This chapter begins by focusing on the different stages of applied research through which a creative innovation will progress. These stages are linked to the common entities that work on the project, namely; the university, industry, and a coalition between the university and the industrial sector.

The role of the university's TTO will also be discussed. As the TTO is the liaison between the university and industry, the effectiveness of this office should be determined. The success factors that are identified in literature are stated and the more relevant of these are further analysed to identify the factors that influence the success of knowledge transferal.

Finally, the chapter discusses the advantages and limitations of universities and industries working together. Some of these aspects can be managed, and others are ethics based. Knowing these advantages and disadvantages is beneficial when reviewing the policies concerning university-industry linkages.

## 6.2 Research and Development

The distinction between basic and applied research was discussed in Section 4.2. It was noted that basic research is mostly conducted by universities. The results of basic research lay the foundation for applied research, but at this stage the technology is still in its infancy, and requires further development. Social returns for basic research is high, but private returns will be low as the technology is still under-developed. Governments, therefore, encourage universities to pursue basic research through subsidies and grant allocation.

Applied research has commercial value, and its development can generate high private returns. There are some government-led incentives to encourage applied research, but this research can be commercialised, which can result in a direct return on investment.

The research and development phase is a very crucial period in the development of any new technology. A working concept has to be generated, tested and implemented into industry in a practical way that can be sold to the market. The R&D stage mentioned in the literature on technology development is mostly focused around applied research. Markman *et al.* (2005) divides the steps into (1) early-stage inventions, (2) proof of concepts, (3) reduced to practice, and (4) prototypes. Figure 6.2 presents a combination of the stages of R&D as is suggested by Markman *et al.* (2005) and Hanssens (2016). Markman *et al.* (2005) and Hanssens (2016) also mention the entities that are involved at the different stages of R&D, but these are generalisations and not necessarily adhere to in practice.

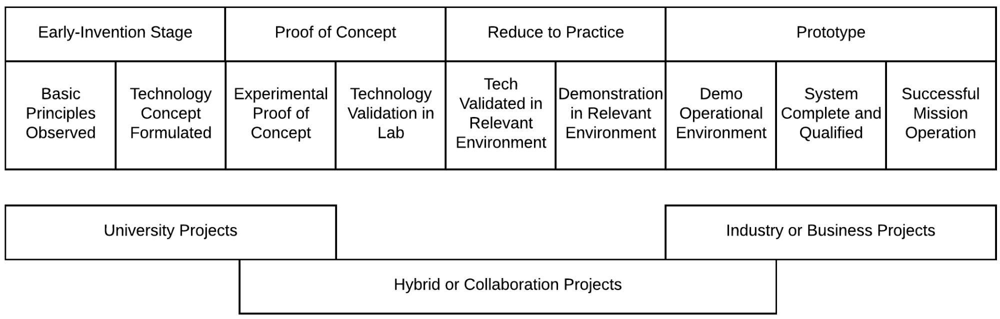


**Figure 6.2:** R&D phase of technology development adapted from Markman *et al.* (2005) and Hanssens (2016)

An early-stage invention is an idea that has been formed with the possibility of working, but requires further development. This part in the technology development stage presents a crude example of what is possible, but the feasibility of the technology is not yet known. The second stage of technology development, the proof of concept stage, displays the technology at the stage where it is starting to unveil the result that was promised. It is still not a guarantee that the technology will be successfully commercialised, but the phase does prove that the invention can work and that it is a viable technology. The reduction to practice, the third stage, constant successes are shown. At this point, the technology has been developed to such an extent that reliable results are produced repeatedly through constant testing. The final stage of technology development, involves producing a prototype. A prototype shows that the invention can be put into practice. It is also a clear demonstration of how the technology can be manipulated to meet the need for which it was designed (Markman *et al.*, 2005).

The stage of development of an invention is one of the key determining factors of the price at which it can be sold. The further a technology is developed, the more it is worth. This is associated with the cost of developing the invention into later stages and the certainty of its successful application. The costs include laboratory equipment, time spent on developing the technology, the raw materials that were needed for tests, and sometimes the cost of the prototypes.

Most of the value placed on these more developed technologies is derived from the reduced risk in later stages of development. If a prototype of the invention can be presented, it offers some tangible proof that it can be applied to practice. Therefore, an invention in the prototype stage will be worth more, as the buyer has a clearer idea of the technology, which reduces the uncertainty that is involved. A proof of concept model, on the other hand, presents the buyer with uncertainty and the risk that the concept might not be able to be commercialised. A product that is in the later stages of development is not free of risk, but there has been more time to identify possible failures that can occur (Jensen *et al.*, 2003).

Jensen *et al.* (2003) states that the quality and reputation of an institution plays a significant role in the selling of technology. Companies are more likely to buy an invention at an earlier stage of development from a reputable institution. If an institution is not well known in the area of technology development, a later stage of development is required before interested parties will be willing to make a suitable offer.

Reputable research institutions also tend to receive higher royalty payments for inventions. Less reputable research institutions would rather request the buyer to fund research than pay royalties (Markman *et al.*, 2005).

Successful TTOs at highly reputable research institutions encourages the disclosure of inventions at the proof of concept stage. This allows them to receive sufficient capital for the invention, and the inventor can then continue on to a new project. Universities want to discover and explore new concepts constantly, and not spend excessive time and resources developing a technology to a stage where it can be commercialised. As universities do not apply the technologies developed commercially, these higher education institutions are not interested in developing old technologies. These are developed by companies that use them through continuous improvement. Selling technologies early in the development stage enables universities to generate funds, while still fulfilling their three-pronged mandate as universities (Jensen *et al.*, 2003).

## 6.3 The Success Factors of Technology Transfer Offices (TTO)

TTOs act as a liaison between the university and the industrial sector. The main purpose of a TTO is to facilitate the transfer of knowledge into industry. However, there are different views on the extent of their influence (Debackere and Veugelers, 2005; Beer *et al.*, 2018; Baya *et al.*, 2011).

Most TTOs limit themselves to only facilitating the interaction between industry and the researcher or research group. They do not normally initiate the process, but assist the researcher in finding a buyer if the researcher approaches the TTO. They will also assist a company in identifying a research group to assist the company with its problem. They distribute their resources towards facilitating actions, such as patent applications, constructing licence agreements, assisting new companies to grow with the new technologies, and drawing up research contracts (Debackere and Veugelers, 2005; Beer *et al.*, 2018; Baya *et al.*, 2011).

Other TTOs do the same as explained above, with the exception that they identify research that has the potential to be commercially applied as most researchers do not approach the TTO about exploiting their research. Some TTOs implement systems in order to increase the amount of research that is identified at the university. This allows the TTO to identify commercial potential in research, link companies that want a specific problem solved to the relevant research group, and set up a collaboration between research groups in different departments with the same research area (Debackere and Veugelers, 2005; Beer *et al.*, 2018; Baya *et al.*, 2011).

Regardless of the way that a TTO operates, there are certain success factors that determine the success of technology transferal. Numerous studies have been conducted on a university's technology transfers processes, and each one has its own identified success factors. Those success factors that are most relevant to this study are identified in this chapter (Debackere and Veugelers, 2005; Beer *et al.*, 2018; Baya *et al.*, 2011).

| Success Factors | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Skilled Human Capital | | | X | X | X | X |
| Business Strategy | X | | | | X | X |
| Intellectual Property Protection | X | X | X | | | |
| Institutional Supporting Policies | X | X | X | | | |
| Availability of Funding | | | X | | X | |
| Supportive Government Policies | | | X | | X | |
| High Real Technology Usefulness | | | | X | | X |
| Effective Communication Industry and University | | | | X | | X |
| Financial Sustainability | X | | | | X | |
| Established TTOs | | X | | | | X |
| Stakeholder Support | X | | | | X | |
| Strong Leadership | | | | | X | X |
| Corporate Capacity to Use Results | | | | X | | X |
| Institutional Prestige | X | | | X | | |
| Networking | | | | X | X | |
| Performance and Benchmarking | X | | | | X | |
| Alignment of Institutional Interests | X | | | | | |
| Transferring of Skills with Technology | | | | | | X |
| Incentives to Encourage Technology Transfer | | X | | | | |
| Company Interest in Final Result | | | | X | | |
| Use of Mature Technologies or Knowledge | | | | X | | |

References:

(1) - York and Ahn (2012)
(2) - Alessandrini et al. (2013)
(3) - Reichelt (2007)
(4) - Barbolla and Corredera (2009)
(5) - Buys and Mbewana (2007)
(6) - Binti and Mohd (2012)

**Table 6.1:** Success factors of TTO *adapted from* York and Ahn (2012), Alessandrini *et al.* (2013), Reichelt (2007), Barbolla and Corredera (2009), Buys and Mbewana (2007) and Binti and Mohd (2012)

Table 6.1 lists the success factors that were identified by the mentioned authors. In total, a combination of 21 success factors was listed by York and Ahn (2012), Alessandrini *et al.* (2013), Reichelt (2007), Barbolla and Corredera (2009), Buys and Mbewana (2007) and Binti and Mohd (2012). All these authors consider the success of a technology purely from an economic perspective. Therefore, a successful technology transfer is a process that provides a return on investment.

Some of the success factors identified were mentioned by more than one author, indicating that multiple researchers have come to the same conclusion. This adds more weight to certain success factors, while others are only mentioned by a single author.

The success factors that are relevant to this study is listed below:

1. Skilled human labour
2. Business strategy
3. Intellectual property protection
4. Supporting institutional policies
5. Availability of funding
6. Supportive government policies
7. Established TTOs
8. Institutional prestige
9. Transferal of skills together with technology
10. Incentives to encourage technology transfer

High real technology usefulness, effective communication between industry and university, financial stability, corporate capacity to use results, networking alignment of institutional skills, companies' interest in final results and the use of mature technologies or knowledge were deemed to be inappropriate for use in this study. The main reason that these have been omitted, is that it is difficult to identify these properties in case studies from either primary or secondary sources.

Some of these factors will have been derived from the specific research team, and the company supporting the technology. The success depends on the specific team itself. Other factors are based on the confidential information not disclosed to the public. The following factors were identified as being of critical importance in the success of technology transfer:

***Skilled human labour***

Skilled human labour was presented as a success factor for technology transfer by four different studies. This indicates that the higher the skill of the people involved, the greater the chances of success for innovative new technology. These skilled people include inventors, researchers and entrepreneurs. The higher the skills of all the people involved, the higher the chance of success. (Reichelt, 2007; Barbolla and Corredera, 2009; Buys and Mbewana, 2007; Binti and Mohd, 2012).

Universities must aim to appoint the correct people in research groups, because this will improve opportunities for developing technologies. However, they must also focus on selecting the correct researcher to develop the technology, as the person would need to be technically skilled, but also be able to sell their product.

***Business strategy***

The importance of having a business strategy was highlighted by York and Ahn (2012), Buys and Mbewana (2007) as well as Binti and Mohd (2012). This business strategy refers to the future plan for the technology only, and not to the business strategy of the TTO, or another part of the university.

It is essential for a business to have a strategy for implementing its technology and how it plans to exploit it. This includes planning for production, and knowing which markets are being targeted with regards to the technology developed.

***Intellectual property protection***

One of the pillars of a university's functioning is research, which is expected to result in new, undiscovered knowledge. If universities do not employ people specialising in intellectual property protection, most of the knowledge that is generated will not be protected (York and Ahn, 2012; Alessandrini *et al.*, 2013; Reichelt, 2007).

Protecting innovation is essential, since once it has been discovered it is easy to replicate. If an innovation is not protected by IPRs, then there is no reason for other companies to buy the technology, because it is public knowledge, and can be used freely.

***Supporting institutional policies***

A university must have policies in place that assist researchers in getting their innovations out in to the industrial sector. Universities have to present researchers with the opportunity to exploit the technologies which they have created (York and Ahn, 2012; Alessandrini *et al.*, 2013; Reichelt, 2007).

***Availability of funding***

Capital is always a concern when dealing with innovation. If there are no funds, the project cannot continue, and the technology will not be developed. Higher availability of funds does not guarantee results for innovation, but the lack of funds can hinder progress significantly (Reichelt, 2007; Buys and Mbewana, 2007).

Funds can be granted through government subsidies that are set apart for innovation. However, the funds mostly consist of a university funds that are specifically allocated for research.

***Supportive government policies***

Because innovation brings higher social returns than private returns, governments have to encourage innovation. The policies that govern research at a national level, are made to steer the innovation in the direction that is most beneficial for the country (Reichelt, 2007; Buys and Mbewana, 2007).

***Established TTO***

As the liaison between universities and industries, the TTO plays an important role. TTOs must spend years building a name for themselves as capable intermediaries between researchers and industry. The stronger the TTO, the more capable it will be of identifying potential technologies and potential partners (Alessandrini *et al.*, 2013; Binti and Mohd, 2012).

***Institutional prestige***

The name of an institution plays an important role in the success of technology transfer, according to York and Ahn (2012) as well as Barbolla and Corredera (2009). A university with a higher ranking, will stand a greater chance of partnering with a company, because its reputation is one of quality.

***Transferal of skills together with technology***

The transferal of skills together with the technologies was only mentioned by Binti and Mohd (2012), who state that key R&D staff working on the research should follow the technology transfer process to ensure its success. Allowing researcher that are familiar with the technology to be involved with the new business can greatly increase the probability of the technology succeeding.

***Incentives to encourage technology transfer***

Alessandrini *et al.* (2013) stated that incentives for the researchers to innovate are important. A university can have all the correct processes in place, but if inventors do not want to sell their inventions, nobody will benefit from the research. As an incentive, an inventor (university researcher) will usually be allocated a part of the funds generated by the exploitation of invention.

## 6.4 Incentives for Industry-University Linkages

Collaborations between universities and companies have been increasing over the last few years, and substantially in some countries, as is shown in Figure 6.3. Collaborating with universities has become a good way for companies to start developing their products and processes. Universities already have numerous laboratories in place, and companies fund universities to research new fields to discover technologies that can be commercialised. When technologies are discovered, a company would then develop the product until it is ready to be commercialised, using its own scientists and researchers (de Freitas *et al.*, 2014; Belderbos *et al.*, 2014).

Collaboration is beneficial for both the university and the company. Universities get access to additional funds by doing research for companies (de Freitas *et al.*, 2014) and companies get access to less expensive, exploratory research, but more importantly they also gain access to students. By collaborating with universities, companies get to meet and work with new students, allowing them the opportunity to identify students that they can employ upon graduation (Belderbos *et al.*, 2014).

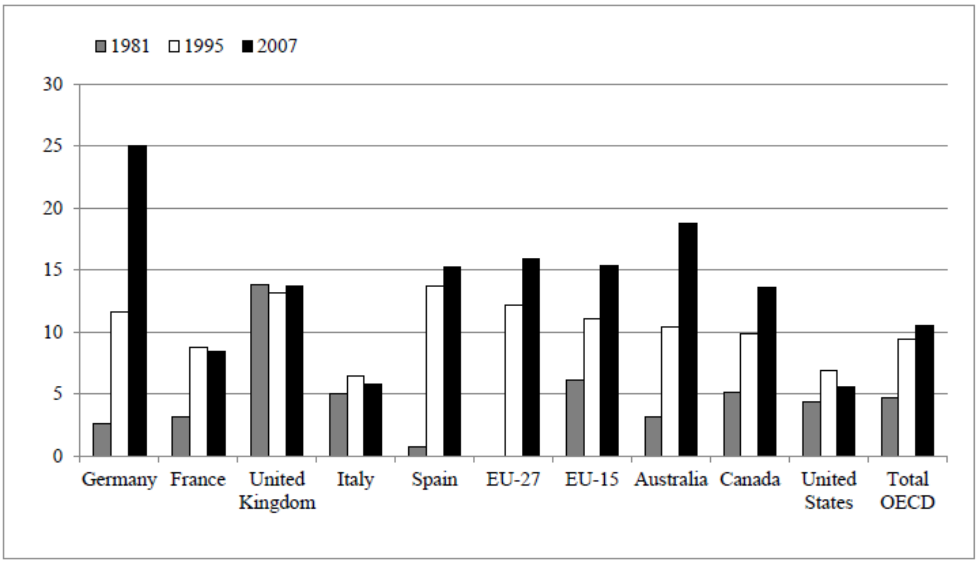


**Figure 6.3:** Percentage of higher education and government R&D financed by industry (OECD, 2013)

Industry-university linkages refer to the research that is conducted for the industrial sector. This can take the form of consultations or research contracts. It can also take the form of research done by the university with the explicit purpose of selling the findings to industries. This type of research usually results in some form of IPR.

The most obvious incentive for universities to collaborate with industries is the funding received from research through commercial applications. Other incentives for collaboration includes developing technologies faster and increasing patenting and spin-off activities (Van Looy *et al.*, 2004, 2006).

Students' exposure to industry is another reason universities encourage research that can be commercialised. Students are essentially the best advertisement for a university, as they represent what is taught at the institution. The performance of the student will represent the quality of the university (Rosenberg and Nelson, 1994; Florida, 1999).

It is also important to remember, that the technology transfer that takes place between industries and universities is not just one directional. The private sector also transfers knowledge to the universities through these collaborations and through the networking that takes place (Van Looy *et al.*, 2004).

The relationship between universities and industries also results in certain problems and limitations. These can arise from the private sector interacting with a research institution that are funded by government. These problems are discussed in the following subsections.

***"Secrecy" problem***

Many companies are either sponsoring research or obtaining a licence for the technology in some or another way. These companies stipulate in the licence agreement which details are made available in the research, and also when it will be released. When a patent is filed, it usually takes 18 months before the patent is disclosed to the public. Companies rarely allow research institutions to publish results before the patent is released to the public. Disclosing the results of research before the patent is released, informs the company's competitors of the technologies being developed by the respective company. Also, there might be additional information on the technology that the university disclosed to the public, as the research contract stipulates it as a trade secret. This creates the "secrecy" problem (Van Looy *et al.*, 2006).

In terms of incentive systems, publication of the study's results constitutes one of the cornerstones of academia. This secrecy problem is seen by academics as a slowing down of the scientific frontier, because new fields of research are being halted by industry forcing the publication of new findings to be delayed

(Florida, 1999; Van Looy *et al.*, 2006, 2004).

***"Skewering" problem***

Universities have always had the mandate to conduct basic research to improve society as a whole. Basic research can be research that has little or no commercial value. It can also be technology that will take years before it can even be considered for use in commercial applications. This research is done with the use of government funds because it is used to steer the technology development in a certain direction (Florida, 1999).

The "skewering" problem refers to the fact that universities are moving away from basic research and placing a stronger focus on applied research. Some researchers believe that this is a very short sighted outlook on research. Since universities are now conducting applied research for industries, they are not exploring new avenues of science and are no longer pointing the way for industries with regard to the direction of future research (Van Looy *et al.*, 2006; Florida, 1999; Van Looy *et al.*, 2004).

***Other concerns***

There are other emerging concerns regarding university-industry linkages, besides the "secrecy" and "skewering" problems. The largest of these involves corporate manipulation. Industries are there to make money, and therefore the most important aspect concerns protecting their own interests. The theory on corporate manipulation is that industries will manipulate the finding to suit them, or suppress it completely (Florida, 1999; Rosenberg and Nelson, 1994; Van Looy *et al.*, 2004, 2006).

Another concern that was raised by Kenney and Goe (2004) concerns the fact that the patents filed by universities are becoming less and less significant in the industrial sector. This has nothing to do with the quality of the research, but rather the fact that companies prefer doing their own research in their core business, and outsource the less intriguing research to external resources. This allows them to keep what they are working on confidential for longer periods of time. Florida (1999) and Van Looy *et al.* (2006) also stated that more university-industry papers are being released than single-university papers. This signifies that, although there are numerous university-industry collaborations, most of the research being done in highly profitable technologies.

The final major concern is the attitude that the university has with respect to intellectual property. The Bayh-Dole act that was passed in the United States of America (USA), has opened many additional doors for funding, but most universities took quite some time to realise the potential that it presented. Until the late 1990's, relatively few universities concerned themselves with this new opportunity to collaborate with industry. It was only in the late 1990's, that universities started to see the impact that this new source of funding had on universities that had taken advantage of it from the beginning.

After these benefits became evident, most universities founded their own TTOs. The market become over-saturated very quickly, which caused competition between universities. Universities started placing a greater focus on these intellectual property agreements, trying to get the most money out of the research that they were doing. Companies then stated that the process of setting-up and negotiating the IPR agreements were so time consuming that the research became quite substantially delayed. This led to a partial breakdown of many relationships between industries and universities, making it difficult for industries to entrust more important research to federally-funded research institutions (Florida, 1999).

## 6.5 Chapter Summary

This chapter considers knowledge dissemination from the perspective of a university. The chapter expands on the type of research that a university focuses on. Although universities are partaking in both basic and applied research, universities generally abstain from the development phase of a technology. Universities are actively rated according to their publication output, and the value of publications diminish significantly the more a technology is developed. Research teams that are involved in the development of a technology usually create as a spin-off company.

Knowledge dissemination from universities is mostly in the form of publications. There is, however, a small percentage of research that can be commercialised and this information must be handled with care, and is usually done by the TTO. As the management of a TTO is important for effective knowledge dissemination, looking at the success factors of TTOs are important. These success factors created a good starting point for the development of an effective knowledge dissemination conceptual framework.

As knowledge dissemination to industry is generally the most controlled, it is important to note the benefits that are associated with these relationships. This chapter expands on the benefits of collaboration for both entities, but also some of the problems that can arise from the collaboration, especially to the university. The main concern is the integrity of the research and the institution.

# Chapter 7

# Conceptual Framework

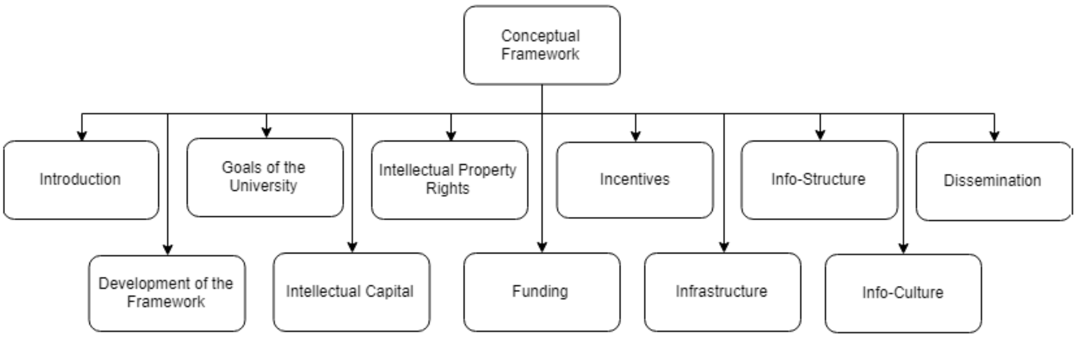


**Figure 7.1:** Overview of Chapter 7

This chapter explains the concepts that were identified in the literature study, and aims to explain the variables that were chosen for the different concepts and how they impact the knowledge dissemination of the university.

1. Section 7.1 – Introduction: An introduction to the layout of the conceptual framework

2. Section 7.2 – Development of Framework: This section will discuss the development of the framework, using the process discussed in Chapter 3.

3. Section 7.3 – Goals of the University: This section aims to identify the goals of the university that are clearly stated in the mission statement of the university. The goals of a university are also determined by the characteristics of the university, and the context within which it operates.

4. Section 7.4 – Intellectual Capital: As intellectual capital is the only commodity that the university has to sell it is measured in this section.

5. Section 7.5 – Intellectual Property Rights: This section focuses on the university's capacity to protect the potential innovations that are generated by the university.

6. Section 7.6 – Funding: This section discusses the availability of money for R&D, not just from the university, but also through local industry. This is all important resources that limit or encourage knowledge dissemination.

7. Section 7.7 – Incentives: These are used to increase the technologies that pass through the TTO

8. Section 7.8 – Infrastructure: These are the guidelines that are set by the government and the university to guide the knowledge transfer in the direction of the university's mission.

9. Section 7.9 – Info-Structure: The aim of this section is to identify the support structure for new technologies and businesses developing from the research conducted at the university.

10. Section 7.10 – Info-Culture: As there are many different culture types that the TTO needs to interact with efficiently. The management of these cultures are critical to the success of knowledge dissemination.

11. Section 7.11 – Dissemination: The option that the university can utilise to ensure that knowledge passes effectively from the university to the general public.

## 7.1 Introduction

The form of knowledge dissemination that this study will focus on is the knowledge which can be sold, generally to the industrial or government sector. This is the type of knowledge dissemination that is generally earmarked for management by a university TTO (Cetindamar *et al.*, 2010; Brouwer, 2005).

The concepts that were identified in the literature review chapters are discussed in details in this Chapter. The concepts that were identified are:

1. Goals of the University

2. Intellectual Capital

3. Intellectual Property Rights

4. Funding

5. Incentives

6. Infrastructure
7. Info-Structure
8. Info-Culture
9. Dissemination

## 7.2 Development of the Framework

***Phase 1: Mapping selected data sources***
The initial selection of data was identified through enrolling in classes that covers technology transfer in universities and the economics of innovation. These classes highlighted relevant concepts, and identified important literature that discusses these topics. From these classes and reading materials, key word could have been identified and search through the use of Scopus and Web of Knowledge. There was an opportunity to obtain literature from both Stellenbosch University's and KU Leuven's data base and library. The key words that were searched on these data bases included:

1. Knowledge Dissemination
2. Technology Transfer
3. Applied vs Basic Research
4. Developed vs Developing Countries
5. Intellectual Property
6. National Innovation Models
7. Publication Incentives
8. Strategic IP Management
9. TTO Success Factors
10. Economics of Intellectual Property
11. Economics of Innovation
12. Research Utilisation

The documents found in these searches also referenced documents that was not found in the search.

***Phase 2 and Phase 3: Extensive reading and categorising of the selected data, and identifying and naming of concepts***

After all the documents were collected, a literature study was conducted to identify all the relevant concept in literature. Upon completion of the literature study, 205 concepts were identified, which will form the building blocks of the conceptual framework. Some of these concepts that were identifies were duplication as different authors from different literature studies referred to similar concepts with different names.

***Phase 4: De-constructing and categorising the concepts***

This phase focuses on the refining process for the concepts. The first step is to break down the concepts and understand the definition of them. Jabareen (2009) suggests doing the following to each of the concepts that is taken from the literature study.

1. Name of the concept
2. Description of each concept
3. Categorisation of the concept
4. Reference of the concept

Once the details of the concepts are known, they are categorised. Concepts are categorised according to each individual role. This process makes integrating the concepts easier, as all similar concepts are categorised together.

(1) Each concept is to be given a name. The names will be used to refer to the whole concept as the framework develops, so it must be clear and to the point. (2) The concept is then clearly defined. This definition will assist greatly with the integration of concepts, as similar concepts can be combined, and their definitions altered to include both entities. (3) The categorisation of the concepts is important, as they would assist with grouping the similar concepts together. The groups that were used in this study included, Economics, Law, Innovation, Intellectual Property Rights etc. (4) Finally, it is important to maintain the references that are included in the original concepts. These references are kept with the original concept, even when it is combined and integrated into other concepts. This allows the references of the concepts to be maintained throughout the study.

***Phase 5: Integrate the concepts***

After the concepts has been named, and clearly defined they can be integrated into each other. The aim of this section is to reduce the number of concepts as much as possible, but also maintaining the core meaning of the concepts as they are reduced. As all concepts were named, categorised and given a description, many concepts were identified as the same and could be integrated into a single concept. With this being done, there still remained 87 concepts.

The concepts were then further evaluated based on the core, overarching concepts. Each of the remaining concepts aimed to achieve. The concepts was then combined into nine core concepts that determines the effectiveness of the knowledge dissemination. Each concept is then defined by principles which are made up of the definitions and descriptions of the initial concepts.

***Phase 6: Synthesis, re-synthesis and making sense of it all***

The purpose of this phase is to refine and alter the definitions based on the original concepts that were identified, to ensure that the essence of these original concepts is not lost in the process. The 8 final concepts are then compared to the work that was done in studies, as was mentioned in Chapter 2. Learning from other studies also assisted with refining the definitions.

***Phase 7 and Phase 8: Validating and rethinking the conceptual framework***

The final integration of the conceptual framework was after the interviews and discussions held with experts in the field. This final input from the experts in the field assisted with a clear definition of each of the concepts and gave perspective on how these concepts functions in real life.

## 7.3 Goals of the University

The Technology Transfer Office (TTO) of a university is a department or a separate entity formed by the university to be the custodians of the technology transfer needs of the university. This entity's primary goal is to provide a service to the university with regards to the university's technology transfer. The effectiveness of the TTO is determined by how well it contributes to the university reaching its goals (Debackere and Veugelers, 2005; Beer *et al.*, 2018; Baya *et al.*, 2011).

These goals are defined by the mission statement of the university, and the financial and knowledge transfer goals of the university. Every action taken by the TTO should be aimed at achieving these objectives, as they are there to serve the best interests of the university.

The goals of the university, although not specifically stated in the university mission statement, are strongly influenced by the size and characteristics of the university. Therefore, this section will also include a discussion of the variables that define the size, research quality and funding of the university (Weckowska *et al.*, 2015).

One of the generic goals of any university is based on the primary pillars of the university, namely, research, teaching and social engagement. If knowledge is disseminated from the university and it does not increase the research capacity of the university, does not present a new concept for teaching or does not contribute to the social engagement of the university, the knowledge dissemination has not been effective.

The university's goals are aligned with the size of the university, both concerning finances and the number of students. These variables will reveal what size of the population is attracted to the university and generated by the university. Another important variable that can be deduced from this will be the capital generated per student, which allows a rough comparison between the universities of all sizes.

The percentage of post graduate students in the university represents the university's capacity for encouraging research and new ideas. Most post graduate students works on a thesis. This is not a perfect variable for measuring the focus of a university, as some universities have a structural post graduate program, but it will give an indication of the focus on research.

The income that is received from the government represents the largest source of income, for public universities. This will indicate the obligation the university has towards the general public. The country in which the university is located will present the major influences that are acting upon the university.

| Concept | Variable | Description |
|---|---|---|
| **Goals of the University** | | |
| | Mission Statement | Primary vision of the university |
| | Number of Students | An indication of the size of a university |
| | Percentage Post Graduate Students | An indication of the maturity of a university |
| | Total Revenue/ Number of Students | An indication of the funds available to a university |
| | Income from Government | An indication of focus on additional funding from industry |
| | Country | Name of country and Global innovation Index Ranking |

**Table 7.1:** Goals of the university

## 7.4 Intellectual Capital

A university, unlike many other commercial entities, can primarily sell knowledge as opposed to physical products. All three of the generic missions of a university, teaching, research and social engagement, are focused on intellectual capital. They all act as a combination of generating and disseminating the intellectual capital of a university (Barbolla and Corredera, 2009).

The management of university intellectual capital can be discussed under three categories, (1) Human Capital, (2) Social Capital and (3) Organisation Capital. Although most intellectual capital cannot be directly sold to external entities, all of them contribute towards building a stronger portfolio to market (Secundo *et al.*, 2017).

Human capital cannot be sold directly, and should be protected by the university. The human capital of the university includes the professors, lecturers, research staff, administration staff and students. The experience of professors, researchers and lecturers in different fields allow the university to have access to specialised expertise when approaching industry (Secundo *et al.*, 2017).

Human capital also refers to the people that are present at the university. One of the main commercial advantages that universities have over other private research entities is that they have a constant flow of human capital through students. However, this study focuses on the staff-members. The data collected from the university relate to the number of staff employed by the university.

Social capital is mainly the reputation that the university has nurtured for itself in the private, public, academic and government sectors. It is strongly dependent on relationships and networks that are built with these communities. This form of intellectual capital cannot be bought or sold as relationships are built on trust which takes years to develop (Secundo *et al.*, 2017).

One method of measuring the social capital of the university is by comparing it to its piers The ranking of universities are different, depending on which entity is doing the evaluation. In this study, it focuses on the Quacquaelli Symonds (QS) university World Rankings. This ranking is quite comprehensive and includes all the universities that was used as both primary and secondary case studies. It also has useful data on each of the universities regarding students and staff member, which was used as data for the study. Finally, the QS University World Rank assigns a single rank to universities ranked up to 400, from which the universities are assigned a rank that includes 10 other institutions. For universities, however, the most important ranking system is the one used by the government of the country in which it is located, as this is usually linked to the grants and subsidies that are allocated to the university.

Finally, organisational capital is the most popular form of intellectual capital that can be sold. Organisation capital includes IPR, databases and research projects. However, there are other forms of organisational capital that cannot be sold, such as government and university processes, research infrastructure, university culture and the research and education processes (Secundo *et al.*, 2017).

Organisational capital consists of numerous elements, and patents merely form a small part of it. However, patents are the easiest element to measure, as it is published by the university, but can also be found in patent databases. The number of patents would give an indication of the university's focus on commercialising research. Its success rate would give an indication of the university's capability to evaluate the technology before registering it.

| Concept | Variable | Description |
|---|---|---|
| **Intellectual Capital** | | |
| Human Capital | Number of Staff | Number of people conducting research |
| | Top 10 h-index scientists employed at the university | Number of renowned scientists at university |
| Social Capital | Policy on Division of Subsidies | Indication of how to maximise income from government |
| | Rank of University | Ranking of university is a summary of how the university is viewed |
| Organisational Capital | Number of National Patents | Number of inventions applicable to local industry |
| | Number of Active Patents | Number of current potential commercial innovations |

**Table 7.2:** Intellectual capital

## 7.5 Intellectual Property Rights

Intellectual Property Rights (IPR) primarily involve the protection of information. IPRs allows the owner to prevent others from infringing on an invention. In industry, IPR are used to deny access of a technology's competitors to other companies. Rights to use IPR, either exclusive or non-exclusive, can also be sold to companies through licensing agreements. These can either be private inventors, or it could be a company that discovered something that is not part of their core business (Knight, 2001; Cetindamar *et al.*, 2010)

As universities rarely commercialise their innovations, their only option to capitalise on the research done at universities is to sell it to external entities. This is done in various ways, but technologies that are not protected can result in diminished returns (Knight, 2001; Cetindamar *et al.*, 2010).

Universities have to protect their innovations, to ensure that they their property. TTOs are generally responsible for managing the protection of a university's intellectual capital by registering the correct IPR for the application. These are mostly limited to patents and industrial designs, as copyright does not need to be registered. They do, however, manage the copyright policy, and ensure that innovations that can be used commercially are stored in this correct manner. These innovations include developments such as software. They can then use these IPRs to manage the dissemination of university's knowledge (Knight, 2001; Cetindamar *et al.*, 2010).

Ownership of the IPR when generated solely through university resources is generally assigned to the university. However, asigning ownership of IPR in a collaborative project is based on negotiations between the parties. Universities, generally, lay claim to the ownership of all the research that is conducted in collaboration with external entities, but offers these external entities options for purchasing the PR (Knight, 2001; Cetindamar *et al.*, 2010).

The management of IPR is critical as protecting the technologies will allow the university to sell something of value. If the technologies are not protected properly, the value of the technology is much lower. It is therefore important for universities to have properly qualified legal staff to ensure that the technologies are adequately protected, which can be seen through the number of legal staff (Knight, 2001; Cetindamar *et al.*, 2010).

IPR generated by an entity is highly dependent on the country in which it is located. Two important variables that are included in this section that is based on the country is the quality of science and education in the country, and the quality of the IPR systems of the country. The quality of the science and education of the country gives an indication of the quality of students that is available to the university. The IPR system of the country influences the willingness of the institution to register new technology. A higher quality of IPR should result in a higher generation of IPR. This can be seen in the number of patents. However, the number of patents can still be low as the university does not focus on patent generation.

The number of spin-offs that has been found at the university will give an indication of the capability of the university to encourage its researchers to commercialise their own research. The success of the spin-off companies will be discussed in Section 7.7, as its success is highly dependent on successfully disseminating knowledge.

When considering the registration of intellectual property, one of the more prominent factors to consider is the registration and maintenance fees. For copyright, the costs are negligible, and even trademarks are relatively affordable. Patents on the other hand can be very expensive, especially considered from a university perspective. South African patents can cost between R200,000 and R500,000 for the patent registration. In the case of industries, this is not a problem, as they can evaluate the value of the technology, and if the value is not sufficiently high they can use other methods to protecting their innovations, e.g. through trade secrets.

In the case of universities, a decision has to be made on whether to patent the innovation or not, before any publications can be made as this would add the innovation to the state of art. Registering a patent for a university also deprives the university of up to R500k in capital that could have been spent on developing the technology. Universities in developing countries, and universities with fewer funding options must take heed not to register patents for the sake of registering patents.

| Concept | Variable | Description |
|---|---|---|
| **Intellectual Property** | | |
| | Cost to register patents | The cost of registering a patent, excluding the re-application |
| | Number of Permanent Legal Staff | Number of staff members constantly working on the protection of IPR |
| | Quality of County's Science and Education | Dictate the resources that is available for generating IPR |
| | Quality of IPR System | The quality of the protection that is guaranteed by the country |
| | Number of Patents | Focus on acquiring Patents |
| | Current number of Spin-Off companies | Focus on commercialising any research (Not just those with IPR) |

**Table 7.3:** Intellectual property rights (IPR)

## 7.6 Funding

In the past the function of universities was to conduct basic research, which still required a great amount of development to become commercialised. Previously, universities received most of their funding from governments, but times have changed. In all countries, governments are encouraging universities to become more self-sufficient, and one of the more obvious methods of doing this is to move some of the research groups from basic to applied research. However, funding for R&D from other sources brings along all the disadvantages and limitations that was discussed in Section 4.2 (Rothaermel *et al.*, 2007).

Money that is used for R&D is very expensive, as there is always a high risk of failure associated with it. For this reason, entities invest in R&D primarily out of internal funds. Spin-off companies are new companies based on new technologies developed from the research conducted at the university; research that has not yet been tested in industry. The first few years will still hold a degree of uncertainty as the technology matures. To encourage the establishment of these spin-off companies from research conducted at the university, universities provide an "innovation" fund to help them in the initial phases of the company start-up process (Gregorio and Shane, 2003).

This innovation fund is essentially an investment from the university at a lower interest rate than the company would have received by other means. The university also acts as a more willing investor since the failure of the business will not be a complete capital loss. The university is compensated for their investment in the company, either through payment back into the fund, or through partial ownership of the company (Gregorio and Shane, 2003).

The funding that is available to universities is highly dependent on the financial state of the country. A country with higher GDP per capita has more capital to spend on technology and knowledge development, including investing in universities. The more capital that is available to the university, the more capital the university has to invest in innovations. This is a problem for universities that have lower incomes. These are the universities that need to develop alternative sources of funding, and yet, they are the ones struggling to put money aside to increase these sources of funding. In general, it take a number of years for a TTO to become sustainable and to grow independent from the university (Hockaday, 2013).

The first variable to consider is the GDP per capita that is available to the country. In recent years, funding from governments have either remained constant, or decreased with each passing year. Investment in research, especially basic research, has a high risk to produce little to no returns. Governments would then rather use the capital to spend it on areas where there can be an immediate effect. Universities then have to turn to other sources to increase the income.

The university has funds that are available specifically for innovation. They serve different goals and different funds encourage different innovations. This study will focus on the number of funds that are available, and also the division of income that is allocated to the fund. This will give an indication of the scale of capital available for innovation, and the focus placed on the growing the fund.

| Concept | Variable | Description |
|---|---|---|
| **Funding** | | |
| | GDP per Capita | Funding available in the country |
| | Innovation Fund | Funding available for new ventures |
| | Division of Income: Innovation Fund | Increasing innovation funding |

**Table 7.4:** Funding

## 7.7 Incentives

Although the university administration and the TTO works towards a specific goal, they can only reach this goal if they involve the stakeholders in the university whose primary purpose at the university is not transfer of knowledge to industry. One of the most common methods used is to create financial incentives (Secundo *et al.*, 2017).

The division of income that is generated by a technology is a popular method employed at most universities. The income is generally divided between three main outcomes namely (1) enriching the inventor, (2) increasing the future knowledge dissemination by channelling funds to support structures and (3) enriching the university. The most commonly used division of funds between these three outcomes normally follows the formula of three equal parts. This is generally not the most effective. If a university gives an outcome a higher percentage than 33.33% it is generally a sign that they place a stronger focus on that outcome (Secundo *et al.*, 2017).

The enrichment of the inventor refers to the percentage of the income that is allocated to the inventor. In theory, if researchers know that they will receive some of the profits generated from their work, they will be more willing to develop technology to the point where it can be sold to industry. University inventors and scientists will then also be more willing to interact with the TTO (Secundo *et al.*, 2017).

Increasing the university's knowledge dissemination can be achieved by improving the infrastructure that supports the dissemination of knowledge. This includes, but is not limited to, enriching the TTO support systems and increasing the "innovation" fund. This will grant the TTO access to greater resources, when future technologies are brought to the market (Secundo *et al.*, 2017; Dallosta, 2011; Czarnitzki and Lopes-Bento, 2013; Payumo *et al.*, 2012).

The final outcome, enriching the university, is the most difficult to manage, as one of the main objective of a university considering technology transfer to industry as usually the generation of additional funds. If a university claims all the profits, additional incentives and infrastructure cannot be created for increasing knowledge dissemination. In some situations, the university administration claims their share and it is used for improving the university or to cover the costs of operation. Some universities use this portion of funding as a way to enrich the university, but also to create incentives (Secundo *et al.*, 2017; Dallosta, 2011; Czarnitzki and Lopes-Bento, 2013; Payumo *et al.*, 2012).

There are numerous incentives that can be used to increase the effective management of a university's knowledge dissemination. Cash incentives are stated in all the IPR policies of the case studies used in this study. The most common division of the income is an allocation to three parts namely the inventor, the university and an innovation fund.

| Concept | Variable | Description |
|---|---|---|
| **Incentives** | | |
| | Division of Income: University | Income for university can be used is incentive faculties and research groups. |
| | Division of Income: Inventor | Income to inventor is a major inventive |

**Table 7.5:** Incentives

## 7.8 Infrastructure

TTOs can only operate between the given guidelines that are set out by themselves, the university administration and the government. These policies determine the power of the TTO, and the methods that can be used to manage knowledge dissemination. The policies used in this study is the policy set out by the government regarding technology transfer from public institutions and IPR policy of the university, which is often set out by the TTO (Francis *et al.*, 2009; Geuna *et al.*, 2008).

The content of these policies can be used to determined the objectives that the TTO and the university aim to achieve. The difference between policies can indicate priority of different aspects of technology transfer. This will however not provide an indication on how strictly these policies are adhered to (Francis *et al.*, 2009; Geuna *et al.*, 2008).

An important aspect of these policies will be to consider the dates that are associated with the policies. This will provide an indication of how old the policies are which would indicate the length of time the university started to see the value of protecting their intellectual capital. The other dates to take note of is the revision of these policies. If they are revised on a regular basis, it will indicate that the university is actively trying to improve its methods of knowledge dissemination (Francis *et al.*, 2009; Geuna *et al.*, 2008).

The infrastructure of the university is determined by the policies that have been compiled. In these policies the university and the TTO will state exactly how support is given to new innovations. These policies will be similar in some instances, such as is demonstrated in Section 9.10 regarding the cost of research and ownership. At the same time, policies are also vastly different to adapt to their unique situations. Each university is unique, and every university will adapt its policy to be best aligned to its own needs.

This section aims not to focus on these policy differences, but instead has placed a focus on the maturity and the flexibility of the universities to adapt their policies. The publishing date of the policy and the latest revision date of the policy will be taken into account for both the national IPR policy and the university IPR policy.

| **Concept** | **Variable** | **Description** |
|---|---|---|
| **Infrastructure** | | |
| Dates of release of the following Policies | National IP Policy | The date that the country identified University IP as a priority |
| | University IP Policy | The date that the University identified University IP as a priority |
| Dates of renewal of the following Policies | National IP Policy | Country continuously improves University IP |
| | University IP Policy | University continuously improves University IP |

**Table 7.6:** Infrastructure

## 7.9 Info-Structure

In this study, info–structure refers to the support that is given to the technologies that arise from the research done at the university. This is not the monetary funding that is provided and discussed in Section 7.7, but instead looks primarily at the support given to the spin-off companies and license agreements arising from the research conducted at the university (Wonglimpiyarat, 2016).

The support that is given by the TTO is not only limited to protecting the technology. Generally, universities have innovation hubs to assist with new businesses start-ups. They provide infrastructure, such as office space and access to the internet, and these new businesses are often surrounded by other innovative businesses which has an encouraging effect (Wonglimpiyarat, 2016).

Some TTOs also provide the spin-off companies with financial and business management consultation. They assist with the development of a business plan and they put spin-off companies in contact with potential partners. Finally, TTOs also connect these new spin-off companies with potential customers or clients, and assist them to build lasting relationships (Wonglimpiyarat, 2016).

When a new spin-off company is founded, most of the staff is comprises of the technical staff members who developed the technology. This results in companies lacking skills in financial and administrative matters. The company also has limited finances, so expenses such as office space and infrastructure would decrease the capital that is available for developing the technology. This gap is usually covered by an incubator, which is a innovative hub of new spin-off companies supported by the university, providing office space, administrative and as financial assistance and network infrastructure to assist new companies in their development.

| Concept | Variable | Description |
|---|---|---|
| **Info-Structure** | | |
| | Number of Business Incubator Centers | Number of spin-off businesses that can be supported |
| | Size of Business Incubator Centers | Number of spin-off businesses that can be supported |
| | Services offered by Incubator Centers | Skills new businesses can develop later |

**Table 7.7:** Info-Structure

## 7.10 Info-Culture

TTOs primarily have three stakeholders, i.e. (1) University Scientists, (2) Firms/ Entrepreneurs and (3) University and TTO staff. The challenge of the TTO comes in with the management of the interactions between these three entities. All three of them have different motives and cultures, and if the TTO does not accommodate all of them, it will be difficult to encourage a collaboration (Bray and Lee, 2000; Beer *et al.*, 2018).

The university scientist is the first stakeholder, and is the discoverer of the new knowledge. Scientists are primarily motivated by recognition in the scientific community. Interacting with the TTO for financial gain is generally a secondary objective for them. Getting university scientists to focus on developing a technology to a point where it is commercially feasible is a difficult task as the culture of university scientists is predominantly scientific (Bray and Lee, 2000; Beer *et al.*, 2018).

Firms and entrepreneurs generally care little for the recognition of the scientific community. Their focus is primarily on the generation of funds, and they have an organic and entrepreneurial culture. They would like to commercialise and sell a technology for the highest profits possible. If they are able to keep certain secrets on the technology, they will do so, since this gives them a market advantage. This is in strong contrast to the motivations of the university scientists. Entrepreneurs' secondary motive is focused on maintaining control of the technologies (Bray and Lee, 2000; Beer *et al.*, 2018).

University and TTO staff act as a liaison between these two entities holding different views. The primary motive of the university and TTO staff is to protect and market the university's IPR that passes through the TTO. Facilitating technology diffusion and securing additional research funding are secondary motives of the university and TTO staff. These entities generally have a bureaucratic culture, as their motives are focused around building and maintaining a relationship with the different entities (Bray and Lee, 2000; Beer *et al.*, 2018).

An important aspect to remember when developing technologies at a university is that if they are not sold, they do not contribute to the university. The technologies need to be sold and dispersed to the industrial sector. As the TTO is an entity founded with the purpose of being a liaison between industry and the university, the number of staff within their commercial, marketing and industry interaction department should far out number the legal staff of the TTO.

For this section, the ratio of non-legal staff to legal staff will be considered.

This will reveal whether the university focuses on producing IPR or selling innovations to the industrial sector. Although the focus of a TTO should be on selling and commercialising IPR, there are funding initiatives that provides incentives for registering patents.

TTO staff should lean more towards constituting non-legal staff than towards legal staff. Legal staff are expensive, and replacing them with commercial staff can increase the efficiency of knowledge dissemination. Technology transfer consultants should also be more focused on commercialising than on protecting the IPR. It is common to see that these consultants come from a legal background, whereas consultants with a commercial background would make the process more effective. Protecting an innovation does not build towards the goals of the university. Commercialising an innovation builds on fulfilling the goals of the university, as it opens up additional funding sources for research, and increase the knowledge and skills of the local industry (Hockaday, 2013).

| Concept | Variable | Description |
|---|---|---|
| **Info-Culture** | | |
| | Number of Staff of the University | Number of Scientists to Interact with |
| | Number of Non-Legal Staff at TTO | Number of TTO Staff that assist with the businesses |
| | Income from Industry / Number of Students | Number of entrepreneurs to interact with. |

**Table 7.8:** Info-Culture

## 7.11 Dissemination

Most of the intellectual capital generated by a university is disseminated to the general public. This can come in the form of publications, where the knowledge can enrich the lives of everyone to whom it is applicable. It can also come in the form of improving the quality of life of the general public (Siegel *et al.*, 2004).

The first form of knowledge dissemination is publication. Publication is strongly encouraged by the university, as many grants and subsidies from governments are awarded based on publications. Publications are also generally used as one of the main variables to determine the ranking of universities. Entities using publications as a variable generally considers two main factors; the first of which is the number of publications and the second being the number of citations of these publications (Checchi *et al.*, 2014).

The other forms of knowledge dissemination can be placed into two categories:

1. Building relationships with industry and government sectors
2. Exploiting relationships with industry and government sectors

The building of relationships is the most difficult to measure, as the type of knowledge dissemination that occurs here can rarely be found on a record shared with the public. Although informal agreements and consultations both cost the companies money, the university generally generates little to no funding in these forms of knowledge dissemination. There are also other forms of knowledge dissemination that build relationships between universities and industry, such as graduate students, but they will not be discussed in this study, as their informal methods of knowledge dissemination are difficult to measure (Barbolla and Corredera, 2009; Debackere and Veugelers, 2005; Rebecca *et al.*, 2013).

Informal agreements between universities and industry are usually made in the form of sponsored research between a research group or a faculty. This type of research rarely results in IPR, but the research group assists the client with a specific problem. This will increase the research group's experience with the company, which can result in more experienced personnel working on future projects. It also allows the company to start building trust in the research group which can result in future licensing opportunities and contract research (Barbolla and Corredera, 2009; Debackere and Veugelers, 2005; Rebecca *et al.*, 2013).

Consultations are focused on a single researcher or research group. Generally, the universities do not charge any additional fees for consultations. The only payments that are to be made to the university constitute the salary costs of the staff members and the renting of any equipment that is used. The consultant can determine any additional costs of the service rendered. This creates an additional form of income for the staff of the university, and opens up affordable expert consultation to industry. This encourages industry to see universities as a source of R&D, and university researchers to seek out industries with which they can interact (Stellenbosch University, 2009; Olupot, 2009; University of Witwatersrand, 2016).

Exploiting the relationship that the the university has built has to be handled with care. If universities are too aggressive to obtain the most funding from an agreement, industries might be reluctant to use universities as viable research partners in the future. If, however, they are too passive, they might not generate any funding. This is not really applicable to creating spin-off companies, but it has a high influence on licensing and contract research (Swamidass and Vulasa, 2009).

Spin-off companies are generated from the research that is conducted at the university. The reason this falls under the exploitation of the relationships is that the university uses the relationship it has built with industry over the years to identify possible clients for the new company. The goal of the TTO is to have high percentage of successful spin-off companies. TTOs would have to accurately identify potential clients to determine the market for the spin-off company (Swamidass and Vulasa, 2009; Gregorio and Shane, 2003; Bray and Lee, 2000; O'Shea *et al.*, 2008).

Although the legal protection of IPR is important, in a university setting, if it is not marketed the technology will be a failure. This is especially important when considering licensing of technologies developed from research conducted by the university (Swamidass and Vulasa, 2009; Weckowska *et al.*, 2015).

Contract research is the product of the relationships built with industry. This can come as a result of other forms of knowledge dissemination, such as consultation. It can also come from industry stakeholders approaching universities as a viable external R&D resource based on the relationships built in the past. Poor management of contract research often damages the relationships between university and industry. This is due to the pressure on universities to increase the generation of their own funding, as they push for agreements that are more favourable to the universities. This leads investment into research conducted at university to become expensive enough that companies would prefer to do the research internally (Swamidass and Vulasa, 2009; Weckowska *et al.*, 2015).

| Concept | Variable | Description |
|---|---|---|
| **Dissemination** | | |
| Publication | Number of Publications | Indication of the Quantity of Research Produced |
| | Number of Citations | Indication of the Quality of Research Produced |
| Spin-Off Companies | Number of Successful Spin-Off | The success of the system. If Spin-Offs are not successful it is a loss for the university |
| Contract Research | Cost of Ownership of IPR | Industries options to purchase an innovation |
| Licensing | Number of Licenses of the University | Indication of successful dissemination of knowledge to industry |

**Table 7.9:** Overview of knowledge dissemination

## 7.12 Chapter Summary

This chapter discussed the development of the conceptual model and the final model. Nine overarching concepts were identified, namely:

1. Goals of the University
2. Intellectual Capital
3. Intellectual Property Rights
4. Funding
5. Incentives
6. Infrastructure
7. Info-Structure
8. Info-Culture
9. Dissemination

The conceptual model that was constructed here aims to highlight that the effectiveness of any action taken to disseminate knowledge will be dependent on the Goals of the University. Effective knowledge dissemination actions taken in one university will not necessarily be effective for another. The Goals of the University in this study is also not limited to the mission statement and the objectives of the university.

# Chapter 8

# Validation of Framework

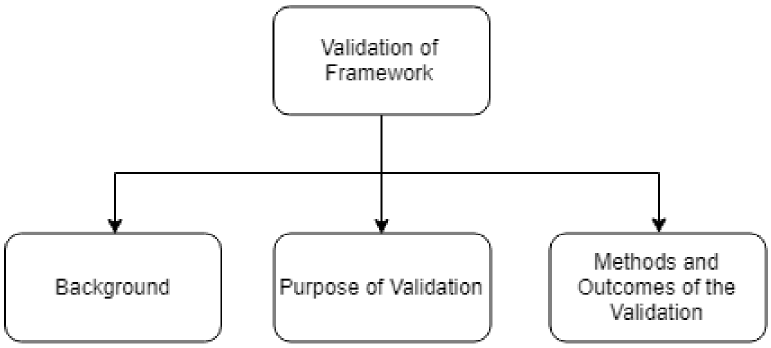


**Figure 8.1:** Overview of Chapter 8

1. Section 8.1 – Background: This section aims to identify the type of research that is conducted, and state the obstacles of validating this type of research.
2. Section 8.2 – Purpose of Validation: This section highlights the importance of validation as it is dependent on so many different different fields of study.
3. Section 8.3 – Methods Employed to Refine and Validate the Framework: This section discusses the final validation process, including the comments on the model from the interviews.

## 8.1 Background

Quantitative research focuses on an empirical investigation based deductive research. This research aims to prove theories based on tools such as statistical analysis, and mathematical models to prove a hypothesis. Validation of a quantitative model can be done through statistical analysis and sample selection. As the data is fixed defined variables, the statistical analysis will provide a more concrete conclusion.

Qualitative research, as is the research used for this study, is more focused on the inductive research, which aims to generate new theories. These theories are generated through the use and interpretation of concepts. Data in qualitative research is concept based, so tools such as coding are used to identify and build a research model or framework.

As a qualitative framework, the research done in this study is based on concepts and ideas from the subject of knowledge dissemination. These concepts have to be interpreted and consolidated into a single framework in which all the different parts communicate to each other. The main concern, regarding the nature of the study, is the number of fields that interact with each other to determine the effectiveness of knowledge dissemination. Therefore, the validation of the framework had to begin at the literature review, as there are so many fields interacting with each other in this framework.

## 8.2 Purpose of Validation

The purpose of the validation is to ensure that the framework accurately represents the interactions that occurs at public research institutions to define effective knowledge dissemination. Knowledge transfer at a university has multiple fields that influences it, and they have to be taken into account when constructing a framework. Validating this framework will then based on opinions of experts in numerous different fields. Technology transfer and intellectual property is a well studied field, as projecting your technologies is key to remaining competitive in the market in an information age. As intellectual property is such a key part in a company's economics, there has been a substantial amount of research done on the subject.

When looking at intellectual property and innovation, the first field of study that was pursued was the legal field. However, when discussions started with other fields, such as economics, technology transfer offices, innovation centres and knowledge dissemination from a public research institution, it became apparent that all the other fields see the legal processes only as the final, and in some cases expensive, paperwork for the innovation or new discovery.

As this is a framework for effective knowledge dissemination from universities, it mainly focused on the knowledge that is managed by the TTO. Universities aim to pass their knowledge that can be commercialised through the TTO, and all the other knowledge are disseminated through publications. The TTO is generally the only entity that can affect how knowledge is disseminated, so the final validation of the framework was done by interviewing a director, a consultant and a marketing expert of different university TTOs located in South Africa.

## 8.3 Methods Employed to Refine and Validate the Framework

When the topic of the study was selected, a literature search was conducted on Scopus and Web of knowledge. Keywords were used such as "effective", "knowledge transfer" and "technology transfer". After the initial literature review was conducted, meetings were scheduled with experts in different fields. These fields included legal, economic, technology transfer, innovation and marketing. After these discussion where held, additional concepts and literature was added to the framework.

After discussions with the numerous experts in the field and the second round of the literature study was conducted, classes were attended that focused on the economics of innovation and the management of technology transfer in an industrial and commercial setting. From this the final round of literature was identified and implemented in the model.

The framework was then refined through interviews conducted with three experts in the field of technology transfer at universities. Most of the prominent universities in South Africa were contacted to and interviews were scheduled with those that responded. The variables that were identified in the literature were consolidated into concepts that were used to construct a conceptual framework. This conceptual framework was then presented to the industry experts, and an iteration was done to include the comments from these experts.

The first interview was conducted with the director of a prominent South African University. He has a B.Eng (Mechanical) and a Degree in Law. He discussed two methods through which commercial interactions were prioritised over IPRs. Firstly, they focus more on marketing personnel than on legal personnel. The non-legal staff outnumber the legal staff at the office with a ratio of 8 to 1. This allows the university to spend a higher percentage of the capital on selling technology than protecting technology that might be sold. Secondly, IPRs, especially patents, are registered only when the university has confirmed if the technology can be commercialised. This is to increase the availability of funds that is allocated to research rather than spending a portion of the funding allocated to the research on protecting a research project which might have no commercial value.

The second interview was conducted with a technology transfer consultant at a second prominent university in South Africa. The interviewee has a Bachelors degree in Law. He discussed the use of patents that currently have no, or little commercial value. The university use these patents to fund future research project that can be commercially viable based on the fact that a patent has already been registered on the technology. This funding is provided by Technology Innovation Agency (TIA) in South Africa.

The final interview was with the commercial manager of the Innovation and Technology Transfer Office at a third prominent university in South Africa. This office also use patent protection to generate funds from TIA to fund additional research.

The questions that were discussed in the interview were open-ended questions, and are as follows:

- How does the TTO align itself with the goals of the university?
- How IPR is used in the TTO?
- How is the relationship of the TTO and Industry managed by the TTO?
- Is this framework an accurate representation for the interactions of the TTO to ensure effective knowledge dissemination?

From these interviews the framework was adapted to include the aspects that were highlighted by these experts in the field. All three experts stated that they do not partner with research that would not either maintain the level of research conducted at the university, or, as is preferred, increases it. The TTO constantly searches for research projects that can develop into multiple projects, and include multiple faculties.

The next item of discussion was the importance of commercialising and marketing the technologies, above protecting them. An IPR is a wasted expense if it does not generate income through licenses. These experts highlighted, which was confirmed in literature, the importance of non-legal staff members. This focus on non-legal staff would mean that the university intends to sell the research, and not just protect it. Non-legal staff are also the key to build relationships with industry partners, which are potential customers for licenses, or clients for contract research.

Finally, the importance of not limiting the view of knowledge to IPR, but as intellectual capital was highlighted, as this would include all that is available to the university. IPR is a small portion of the knowledge that is generated by the university, and this should be noted. The validation that was done was through implementing the framework into two case studies, which will be discussed in Chapter 9.

## 8.4 Chapter Summary

Most of the work done on the framework was focused around refining the framework. This was done through literature studies, attending classes and having discussions and interviews with experts in the field. Through collecting all this data, the framework was refined to the state in which it is in now.

A validation of the framework was done through the practical implementation of the framework in two primary case studies. This is a limited approach to the validation of the framework and the future work should include further validation of the framework. The feedback from industry experts, is also subjective, and they are all based on their experience in developing countries.

# Chapter 9

# Case Study

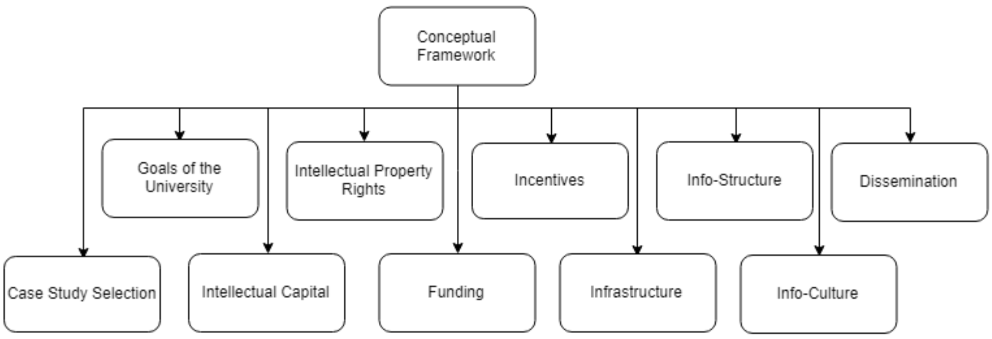


**Figure 9.1:** Overview of Concepts

The purpose of this chapter is to analyse cases studies using the conceptual framework that was developed in Chapter 7 from the literature reviews conducted and described in Chapter 4, Chapter 5 and Chapter 6. The conceptual framework aims to incorporate the elements that impact the TTOs strategy for effective knowledge dissemination. The purpose of the case studies is to evaluate the conceptual framework on a practical case and gain insight regarding the practices at different institutions that operate in different environments.

1. Section 9.1 – Case Study Selection: This section describes the methodology that was adopted for case selection dividing the cases between primary and secondary cases.

2. Section 9.2 – Goals of the University: This section describes the variables that were identified in Section 7.3 to illustrate the impact that the goals of the university's goals have on its strategy of knowledge dissemination.

The goals include the mission and vision of the university, but also includes descriptions of aspects such as university's size and revenue, as these variables exert a strong impact on its method of operation.

3. Section 9.3 – Intellectual Capital: This section deals with the management of the primary asset that the university can sell. Intellectual capital is divided in to three types, (1) Human Capital, (3) Organisational Capital and (3) Social Capital.
4. Section 9.4 – Intellectual Property Rights: If the research conducted at the university leads to an innovation that can be sold to industry, IPRs are used for protection.
5. Section 9.5 – Funding: Research is expensive, and this section will determine the funding that is available for the development of technologies.
6. Section 9.6 – Incentives: The section will consider the incentives that are created by the university to increase the knowledge generated by researchers at the university.
7. Section 9.7 – Infrastructure: The infrastructure is primarily focused on determining the university's maturity and flexibility, by evaluating the age of the IP Policy, and the most recent date that it was reviewed.
8. Section 9.8 – Info-Structure: This section focuses on the incubators or innovation hubs that are located at the universities and the capacity of universities to support new spin-off companies.
9. Section 9.9 – Info-Culture: The liaison between the university and industry constitutes the staff at the TTO. It is therefore important to look at the ratio of staff that do not focus on the legal elements as these personnel focus on building relationships with industries.
10. Section 9.10 – Dissemination: This section aims to evaluate the different avenues of dissemination, and how universities are utilising them.

## 9.1 Case Study Selection

For this study, primary and secondary cases were selected for the verification and testing of the constructed conceptual framework and evaluate the way universities in different environments approach knowledge dissemination. The primary cases are the main focus of this chapter, and are limited to two university TTOs. The secondary cases have been selected to provide a more representative range of the values of the various variables of the framework. Since the primary cases are considerably different from each other, a comparative analysis was done with the secondary cases.

### 9.1.1 Primary Case Studies

This first of the primary cases selected was Stellenbosch University, in South Africa. Stellenbosch University is one of the top universities in South Africa as it is ranked third in South Africa (Carolissen, 2017; Burger, 2017; Steyn, 2017; Price, 2017).

Stellenbosch University's TTO, InnovUS, has also played a major role in the development of the other universities' TTOs in South Africa. There are numerous staff members at other universities' TTOs that have worked at InnovUS.

Stellenbosch University has the oldest and one of the most developed TTOs in South Africa. This office has spent years cultivating relationships with industry partners, and maintaining these relationships. They effectively support new companies that start from research that is developed by the university, and put them into contact with potential industry partners. All these factors render Stellenbosch University a prime candidate to investigate with regards to doing a survey of the effectiveness of knowledge dissemination practices in developing countries (InnovUS, 2017).

The Katholieke Universiteit Leuven (KU Leuven) is the second primary case study that will be discussed. According to Ewalt (2018), KU Leuven is the most innovative university in the world, including private universities and universities in the United States of America. Using an innovation ranking for effective knowledge transfer is more relevant than using other university ranking systems, as innovation ranking takes a deeper look at the impact that universities have on local industry.

KU Leuven Research and Development (LRD) is the TTO of KU Leuven. This is a highly respected TTO in the university sector. They are also known to assist other universities with establishing their own TTOs, including InnovUS at Stellenbosch University. The LRD, which is based in Leuven, also services all the entities that make up the KU Leuven Association (LRD, 2016).

LRD has built up an effective organisation with a strong relationship to industry. The LRD has always been one of the most effective TTO, and they continue to improve, as can be seen in the last few years (LRD, 2016). When the initial case selection was done in 2016, KU Leuven was ranked $16^{th}$ in the world (Ewalt, 2015). It was the most innovative university outside of the United States, Japan and the United Kingdom. When the case study was completed, the 2017 data was used and the LRD has assisted in making KU Leuven the most innovative public university in the world. In total LU Leuven was ranked $6^{th}$ in the world, with the other 5 universities being private universities located in the United States (Ewalt, 2017). The final data from 2018 stated that KU Leuven has now become the most innovative university in the world, according to Reuters Innovative University Rankings (Ewalt, 2018).

The full details pertaining to the two primary case studies are presented in Appendix C and the data that will be used for the analysis is presented in Appendix D. For the primary cases, all the data that was required for the study could be collected, as there was a opportunity to collect data that was not available on the university's website through interviews with various subject matter experts as the author had completed extended research stays at both case study universities.

### 9.1.2 Secondary Case Studies

The two primary case studies are located in two completely different economic and social environments, as one is located in a developing country in Southern Africa, while the other is located in a developed country in Western Europe. A direct comparison of the data of these two case studies is problematic if their environments are not take into consideration, since they have different objectives and different challenges to overcome. Therefore, the secondary case studies were selected to provide a broader frame of reference for the data presented in the primary case studies. These secondary cases indicate which variable values are relatively low/high compared to cases in similar environments with similar performance outcomes.

The secondary case studies were selected based on two different methods. The cases selected are not random, but were selected on the basis of specific criteria. The selection process was done by (1) selecting universities from similar environments and observing the different performance levels of the case studies within these environments and (2) selecting universities with similar performance levels and observing the different environments in which they are located.

The method that was used to select the secondary case studies with constant environments was based on location. When comparing universities that are exposed to the same environment to determine what differentiates its performance from that of another, the country that the university is located in enables the study to control for a variety of environmental factors that are likely to be similar between the observed cases. Therefore, the first aspect that was used to select secondary universities is the country in which the universities are located. In the case of Stellenbosch University, five of the most prominent competing universities from the country were selected as comparative cases that operate in the same environment.

In order to select cases with which KU Leuven could be compared, other universities from Belgium were selected. In particular, only universities from the Flanders region in Belgium were considered, as there are major economic and social differences between the Flemish (Flanders), the Walloon (Wallonia) and the Brussels Capital regions of Belgium (Hanssens, 2016). The final selection of universities based on this first selection criteria were thus:

1. South Africa
    a) University of the Witwatersrand
    b) University of the Free-State
    c) University of Johannesburg
    d) University of Pretoria
    e) University of Cape Town
2. Flanders, Belgium:
    a) University of Antwerp
    b) University of Ghent

The next step was to select the secondary case studies based on having similar performance levels to the primary cases and evaluating the environments in which they are located. The case selection based on the performance of the universities was done on the data collected in 2017. The most effective method for determining similar performance levels in universities is through university rankings.

The first is based on the Reuter's Most Innovative Universities rankings, that was performed in 2015. This university ranking list was limited to 100 universities, and so Stellenbosch University was not on the list. KU Leuven was ranked $16^{th}$ in the world. The universities that were ranked similarly to KU Leuven were selected. They were all located in the United States of America and included the following (Ewalt, 2015).

1. Washington State University
2. North Carolina at Chapel Hill
3. Duke University

The innovation rankings of universities would be a better tool for case selection than other university rankings, but the innovative university rankings do not exceed a 100 university. Therefore, the Quacquarelli Symonds (QS) Rankings were also used. This ranking system focuses on publications and citations as its main variable for determining the ranking of the university, but it also includes variables such as quality of research, number of students and percentage of post-graduate and international students (Quacquaelli Symonds, 2017). Again, the universities were selected based on the ranking of the primary case studies. In the case of KU Leuven, the data for the top-ranked universities are available on-line, but the lower ranked universities that are similar to Stellenbosch University have less data available. Many universities that were similar to Stellenbosch University had to be removed from the study because of the lack of data. The selection of most similar universities with similar rankings and with sufficient data availability were:

1. Compared to Stellenbosch University
   a) Qatar University
   b) Australian National University
   c) University of New South Whales
2. Compared to KU Leuven
   a) Imperial College of London
   b) University of Zurich

The detailed data for these cases is presented in Appendix D. Not all the data could be collected for these cases, as some information had not been disclosed to the public. Some of the data are only available to students and staff members of the institution. Therefore, not all the secondary cases are represented in each part of the analysis, as there was insufficient data available for each variable.

## 9.2 Goals of the University

The goals of the university define what can be considered to be effective dissemination of knowledge from a university. This comes in the form of the mission, vision and objectives of the university. These are the over aching goals of the university and knowledge dissemination can only be effective if it strives to achieve objectives that are aligned its goals.

Stellenbosch University's mission states that it aims to develop its staff and students into thought leaders of higher education. The university does research, assures quality and provides the necessary tools and support to its staff and students to enhance their own learning and success. From this it can be deduced that all actions taken by Stellenbosch University should be considered in the interest of improving the skills, learning and success of the university's staff and students (Stellenbosch University, 2016).

KU Leuven sees itself as both a basic and applied research institute, focusing on research in both areas. It strives for cooperation between departments, but also internationally, forming strong research partnerships both locally and abroad. They encourage personal initiative and aim to develop a critical reflection in a culture of idea exchange, cooperation, solidarity and academic freedom. It would thus seem that while Stellenbosch University aims to increase the skills of the individuals to strengthen the institute as a whole, KU Leuven has a stronger focus on increasing and strengthening the networking and relationships of the university (LRD, 2016).

The number of students studying at a university is not dependent on whether it is located in a developed or developing country. For example, KU Leuven has a similar number of students to the University of Pretoria, and Stellenbosch University has more students than universities such as Antwerp University, Duke University and Imperial College of London. Post-graduate students generally constitute a larger percentage of a university's student population in a developed country than in a developing country. The highest percentage of post graduate students in South Africa is found at Stellenbosch University and the University of Cape Town, with 28% post-graduate students. Of the universities selected for this study located in developed countries, only Washington State University has less that 31% post graduate students. KU Leuven and Duke University have in excess of 50%.

Figure 9.2 gives an indication of the funds that are available to universities. The universities on the left are located in developing countries, and the four universities on the right are located in developed countries. When comparing the funds available for the university per student, it can be seen that the universities in the developed nations have much more money available to spend on research than universities in developing countries. The funds that are used here constitute the total revenue of the university.

Figure 9.2 uses abbreviations to symbolise each of the universities. The key to these abbreviations is given in Table 9.1.

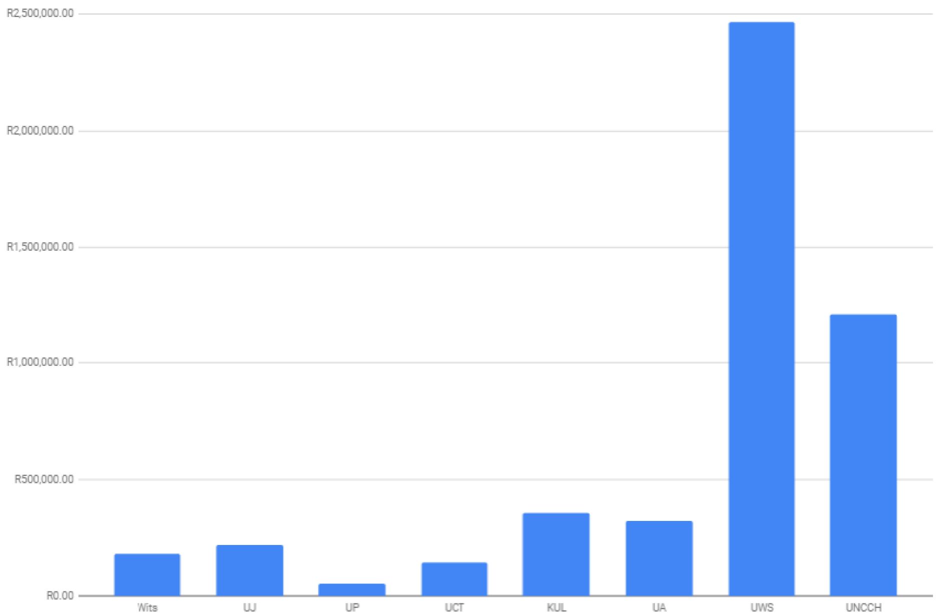


**Figure 9.2:** Revenue that the university generates in relation to the number of students

**Table 9.1:** Abbreviations

| Abbreviation | University |
|---|---|
| Wits | University of Witwatersrand |
| UJ | University of Johannesburg |
| UP | University of Pretoria |
| UCT | University of Cape Town |
| KUL | KU Leuven |
| AU | Antwerp University |
| UWS | Washington State University |
| UNCCH | University of North Carolina, Chapel Hill |

It can be seen from Figure 9.2 that the universities in developed countries have substantially more funds available per student than universities located in developing countries. This means that universities in developing countries have less funds available for research as they have to spend it on teaching and developing their students.

## 9.3 Intellectual Capital

Intellectual capital needs to be managed by the TTO. A very small portion of the intellectual capital is found in IPRs. As is discussed in Section 7.4, for purposes of this study intellectual capital is divided into three types, namely, (1) Human Capital, (2) Organisational Capital and (3) Social Capital. IPR only forms a small part of the intellectual capital that is categorised under organisational capital.

The number of patents registered seems not to be influenced by the location of the university, as Stellenbosch University has filed the third most patents in the case studies that were conducted. The number of patents is therefore strongly dependent on the focus of the university. Both KU Leuven and Stellenbosch University are strongly focused on TTO development, which would naturally lead to a larger number of patents. These are universities that are focusing on increasing the stream of income from industry.

In the case of universities that are located in developing countries it it important that the patents registered have a high success rate, and a high percentage of the successful patents are registered as PCT patents. There should also be less patents registered in developing nations and there should be a higher certainty of success and value upon patents registration, as the money needs to be spent more judiciously. Developed nations can register a larger number of patents, with lower success rates, as it would give them exposure and lend a certain prestige in industry. From cases selected for the study, it can be seen in Table 9.2 that this is true, as the success rate of patents from South African Universities is higher than those from other countries.

**Table 9.2:** Organisational capital: Patents

| University | # Patents | % PCT | % Success |
|---|---|---|---|
| Stellenbosch University | 299 | 41% | 51% |
| KU Leuven | 623 | 59% | 33% |
| University of Witwatersrand | 100 | 27% | 52% |
| University of Johannesburg | 12 | 42% | 41% |
| University of Pretoria | 34 | 18% | 52% |
| University of Cape Town | 97 | 21% | 67% |
| Duke University | 783 | 34% | 34% |
| Washington State University | 174 | 43% | 43% |
| University of North Carolina at Chapel Hill | 90 | 81% | 20% |
| University of Zurich | 105 | 42% | 42% |

## 9.4 Intellectual Property Rights (IPR)

When considering the cost of filing for patents, all values were converted back to rand values with the following exchange rates used: 1 *Euro* = R17.4, 1 *US Dollar* = R14.88, 1 *Qarari Riyal* = R4.09, 1 *Australian Dollar* = R10.70, 1 *British Pound* = R19.59, and 1 *Swiss Franc* = R14.90. The analysis excluded maintenance fees and legal fees for registration, and included only the fees that need to be paid to the patent office for registering a single national patent.

Figure 9.3 gives a summary of the costs incurred when registering a patent. It can be seen that there is a vast difference in the costs of registering a patent between different countries.

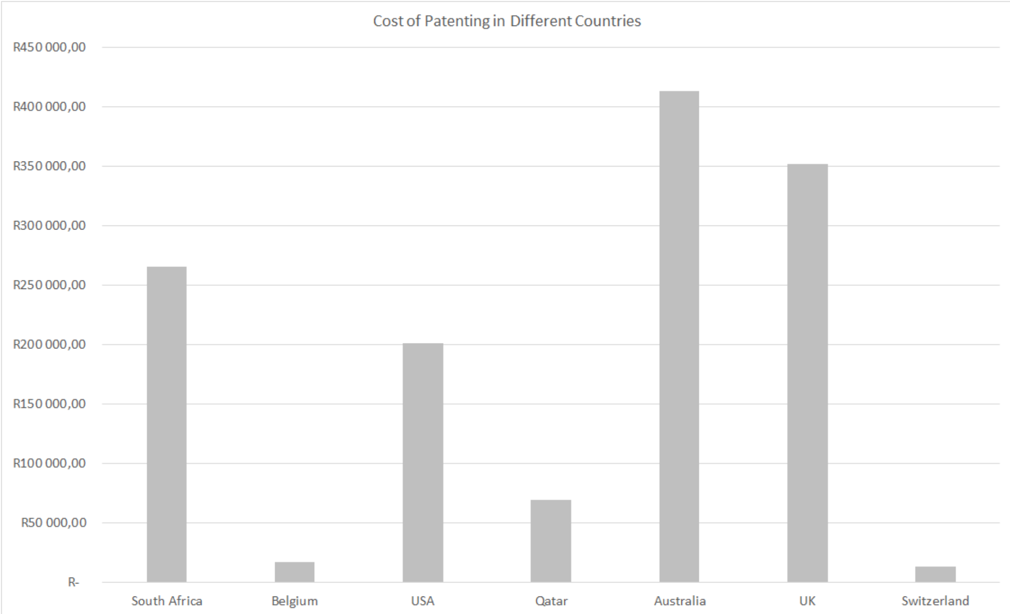


**Figure 9.3:** Cost of patenting in different countries

The number of legal staff was used as a criterion as it contributes to the ease with which the university can register IPR. The greater the number of permanent staff kept by the university, the less costly the legal advice for filing IPRs. A further analysis of this variable is performed in Section 9.9, by comparing this number to the number of non legal staff present at the university.

The Technology and Human Resource for Industry Program (TRIPS) agreement was put in place to ensure that countries adhere to a certain standard regarding IPR. Countries with a low level of education and science development, would be better served by having a less developed IPR system as this would allow the country to use technologies more easily to develop their technological capabilities. Highly developed countries want to protect their innovations as much as possible, so their IPR systems must be effective Czarnitzki *et al.* (2015).

When looking at the quality of the science and education systems of South Africa, it can be seen that they are ranked 114$^{th}$ in the world by the Global Competitive Index. This is out of all the countries in the world. Yet, they have an IPR quality ranking of 36. When comparing the rating that is given, it is the same rating as that rewarded to Belgium. So although Belgium and South Africa are ranked differently in terms of competitiveness, their IPR systems are up to the same standard. Belgium, however, has a ranking of quality of science and education of 8, placing it in the top ten countries in the world

(Schwab, 2015).

## 9.5 Funding

With Belgium being a developed country and South Africa being a developing country there is a big difference between the two. South Africa has a GDP per capita of little over 10% of that of Belgium. This is not unexpected, but it does highlight the differences of finances that are available to the universities.

Table 9.3 provides a breakdown of the percentages of the different sources of income. In this study, it is assumed that the university generates its revenue from 4 sources, which are as follows:

1. Industry: This is made up of sponsorship and donations given by industry to the university. This also includes contract research and sponsored research.
2. Government: This is the portion that is allocated to the university through grants and subsidies.
3. Student-fee: Paid by the students to study at the institution.
4. Investment: This is the income that is generated from licenses, equity in spin-offs, and other investments of the university.

Student fees form a smaller portion of the income of Stellenbosch University when compared to other universities in the country. Stellenbosch University has a strong focus on generating income from investments and other endeavours, as the other sources of income are limited.

KU Leuven, on the other hand, has a high percentage of income from the government, but receives almost no income from student fees. They therefore use their connections with industry to increase their income. Both Stellenbosch University and KU Leuven have a higher percentage of income from their investments, than from donations from the industrial sector.

**Table 9.3:** Universities' sources of income

| University | % Industry | % Government | % Student Fee | % Investment |
|---|---|---|---|---|
| Stellenbosch University | 9% | 40% | 27% | 23% |
| KU Leuven | 16% | 67% | 0% | 17% |
| University of the Witwatersrand | 21% | 31% | 43% | 6% |
| University of Johannesburg | 12% | 42% | 41% | 5% |
| University of Pretoria | 3% | 58% | 39% | 0% |
| University of Cape Town | 11% | 46% | 44% | 0% |
| University of Antwerp | 19% | 77% | 0% | 4% |
| Washington State University | 18% | 45% | 24% | 13% |
| University of North Carolina at Chapel Hill | 41% | 38% | 20% | 1% |

It can be seen that both primary case studies have at least one source of funding that is limited.

## 9.6 Incentives

Stellenbosch University and KU Leuven both have altered the ratio of dividing income based on the profitability of the innovation. As the innovation starts generating more and more funds, the inventor will receive a smaller portion of the income, and the income is allocated to other divisions. In both of these cases, the difference is given to the innovation fund, which increases the university's capacity to support new innovations.

As is stated in Section 7.7, the income is generally divided between three main outcomes, namely (1) enriching the inventor, (2) increasing the knowledge dissemination and (3) enriching the university. As is standard, Stellenbosch University divided the income between these three allocations, as can be seen in Figure 9.4. One part is allocated to the inventor and another to the innovation fund, but Stellenbosch handles the portion to be allocated to the university in an interesting way.

Instead of using the capital as an income to the university as a whole, it allocates this portion to the faculty and research group that developed the innovation. This allows the university to continue receiving an income from the technology, but the funding is used specifically by the departments that generated the income. This provides an additional channel of incentives, as it is now not only the inventor who is rewarded, but the whole division. This results in the creation of "pulling" incentives from the TTO in the form of income given specifically to the inventor, but also a "pushing" incentive as the research group and faculty will encourage researchers to communicate with TTOs.

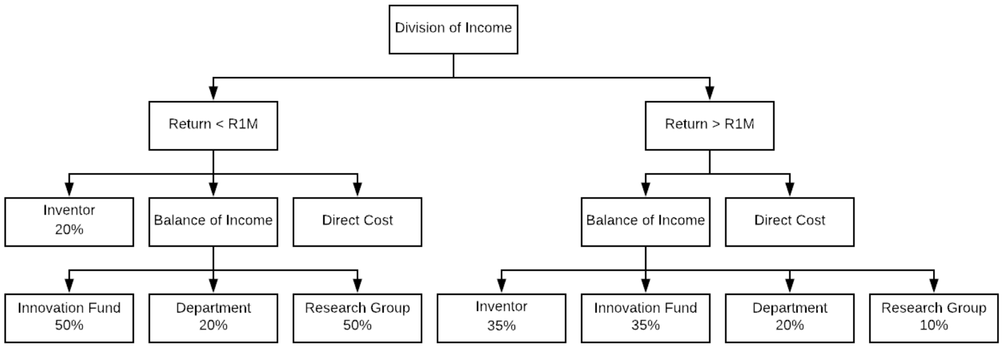


**Figure 9.4:** Division of income: Stellenbosch University *adapted from* InnovUS (2017)

KU Leuven takes up a small fixed portion of the income for itself and LRD. The rest of the income is then divided between the inventor and the innovation fund. This gives the university more funding which it can allocate to inventors in the lower income innovations.

The LRD has a staff of over 140 people, with 90 of them being permanent staff members. This comprehensive staff structure allows the LRD to communicate more effectively between departments, and identify potential research projects that can be combined into collaborative projects. Most of the capital of KU Leuven, as can be seen in Figure 9.5, is focused on the inventor and innovation fund. The higher the profitability of the innovation, the larger the portion of income allocated. The high percentage of income allocated to the inventor in the lower value innovations, creates incentives for researchers to present their findings, even if the returns might be small.

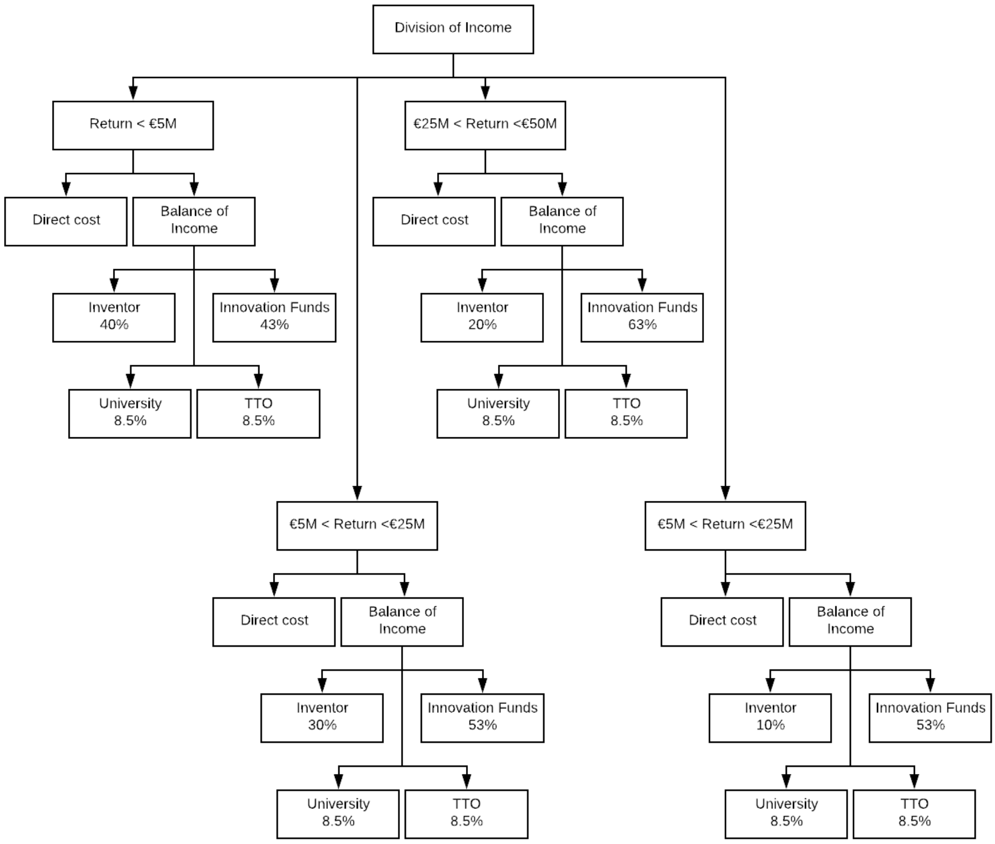


**Figure 9.5:** Division of Income: KU Leuven*adapted from* LRD (2016)

## 9.7 Infrastructure

The nature of TTOs is such that any action to change the process has a delayed effect. For example, both Stellenbosch University and KU Leuven seem to have been proactive in developing an IPR policy a few years before the national IPR policies were changed to allow universities to deal in IPR generated from public funding. These proactive policies gave the universities time to develop other aspects of knowledge dissemination before IPR became available as a negotiation tool. This is a prime example of how, by anticipating change and adapting to it, entities can be allowed to take the lead in certain situation.

Also, it seems that none of the South African universities have recently updated their IP policy. This signifies insufficient flexibility to deal with the constant changes in the country and the university itself. As South African Universities have not had active TTOs for a long time, this will only become evident in the future. It is also important to note that South Africa as a nation has revised its IP policy from public funded institutions in 2017, and none of the universities have adapted their policies.

**Table 9.4:** Published date and revision date of the national and university IPR policy

| | National Policy | | University Policy | |
|---|---|---|---|---|
| University | Publish | Revision | Publish | Revision |
| Stellenbosch University | 2008 | 2017 | 2004 | 2010 |
| KU Leuven | 1991 | 2017 | 1972 | 2017 |
| University of the Witwatersrand | 2008 | 2017 | 2010 | 2012 |
| University of the Free State | 2008 | 2017 | N\A | 2012 |
| University of Johannesburg | 2008 | 2017 | 2007 | 2013 |
| University of Pretoria | 2008 | 2017 | 2008 | 2013 |
| University of Cape Town | 2008 | 2017 | 2011 | 2011 |
| Washington State University | 1980 | 2017 | N\A | 2017 |
| Duke University | 1980 | 2017 | N/A | 2017 |
| Australian National University | 2008 | 2017 | 2008 | 2017 |
| University of New South Wales | 2008 | 2017 | 2013 | 2018 |

## 9.8 Info-Structure

Stellenbosch University has one incubator called the LaunchLab, and it houses 215 people. Some incubators have a limit on how long spin-off companies can utilise them. For example, a spin-off company at the LaunchLab has 3 years to develop into a functioning, self-sustaining business. KU Leuven, on the other hand, has 2 incubators, i&l Leuven and Bio-Incubator Leuven, with a third one under construction. KU Leuven aims to move the spin-off companies into self-sustaining businesses and assists these businesses with developing and maintaining their business plans, but they do not have a set time in which the spin-off companies have to become self-sustaining. KU Leuven has 4100 people working within the companies located at these incubators.

## 9.9 Info-Culture

The number of spin-off companies gives an indication of the support that is given to companies that develop from university research. A small university with a large number of spin-offs gives an indication of strong support provided to these entities. A variable that may have shown better results constitutes success and failure rates, but this data is not readily available. As it is expected, all the universities in developing countries have a small number of spin-off companies. What is interesting is that although there are, as expected, universities that generate large numbers of spin-off companies such as KU Leuven, Ghent University, Washington State University and the University of Zurich, there are also universities in developed nations that have a relatively low number of spin-off.

**Table 9.5:** Non-legal : Legal ratio of staff members at the TTO

| University | NL : L |
|---|---|
| Stellenbosch University | 4:1 |
| KU Leuven | 8:1 |
| University of the Witwatersrand | 5:1 |
| University of the Free State | 4:1 |
| University of Pretoria | 1:3 |
| University of Cape Town | 7:3 |
| Antwerp University | 2:9 |
| Ghent University | 22:9 |
| Washington State University | 11:8 |
| Duke University | 43:3 |
| Australian National University | 6:1 |
| University of New South Wales | 7:1 |
| Imperial College London | 9:4 |
| University of Zurich | 14:1 |

**Table 9.6:** Number of spin-offs

| University | # of Spin-Offs |
|---|---|
| Stellenbosch University | 24 |
| KU Leuven | 110 |
| University of Witwatersrand | 23 |
| University of Cape Town | 19 |
| Antwerp University | 32 |
| Ghent University | 105 |
| Washington State University | 915 |
| Duke University | 63 |
| Imperial College London | 59 |
| University of Zurich | 206 |

## 9.10 Dissemination

This sections aims to measure the knowledge that is disseminated from the university and how effective it is. It will focus on publications, informal agreements and consultations and licensing

***Publications***

The number of publications is a variable that is used in most ranking systems. As discussed in Section 9.3, some countries require high quality publications with high citation statistics, and some countries only require a large number of publications. The number of publications is taken for the last five years for the institution as per Web of Knowledge.

**Table 9.7:** Ratio of publications to staff member

| University | # Publications / # Staff |
|---|---|
| Stellenbosch University | 25.88 |
| KU Leuven | 11.67 |
| University of Witwatersrand | 7.014 |
| University of Cape Town | 20.08 |
| Antwerp University | 9.40 |
| Washington State University | 13.02 |
| University of North Carolina at Chapel Hill | 14.9 |
| Duke University | 27.85 |
| Australian National University | 27.57 |
| University of New South Wales | 22.95 |
| Imperial College of London | 24.86 |
| University of Zurich | 9.67 |

Table 9.7 illustrates that Stellenbosch University has a higher number of publication per staff member than KU Leuven. This was an expected result, since Stellenbosch University gets evaluated based on the number of publications. It can also be seen that KU Leuven, Antwerp University and the University of Zurich all have rather low ratios, whereas Stellenbosch University, the University of Johannesburg, the University of Pretoria, and the University of Cape Town all have comparatively high ratios.

***Informal agreements, consultations and contract research***

The stance adopted on these three areas were found to be similar in all the policies that were reviewed for this study. Informal agreements are not discussed in the policy. Furthermore, they are difficult to manage as there is no central point of reporting. These agreements are managed by each department or faculty, and are used for building relationships with industry with the expectation of forming research contracts with them in future.

The only item discussed with regard to informal agreements involves the serendipitous IPR that can result from these informal agreements. In general, the IPR policies state that, unless otherwise specified in a contract, any new

IPR that is discovered through use of the university equipment or staff working on university time, is owned by the university. Consultations, in essence, constitute the hiring of expertise on existing knowledge, so there is no expected IPR that can be developed through a consultation, but if there is, the same conditions will apply as above.

The cost of consultations is usually low. In the policies reviewed, the cost of consultation is left to the consultant to determine. The university only expects to be reimbursed for the hours that the staff member worked on the consultation during normal working hours, and the renting of the equipment used for the consultation. This arrangement gives staff members a potential additional source of income – allowing the university to create incentives for interacting with industry in the building of relations.

This study's focus on contract research was mostly centred around the cost of research and the cost of ownership. Again, these are generally the same in all the policies that were reviewed. These policies generally divide the cost of research into types, direct costs and indirect costs.

Direct costs are all the costs that can be directly linked to the project. These costs generally include the costs of statutory protection of IPR, accounting fees, the defence of IPR, legal advice, and any cost directly incurred in respect of marketing. The direct costs are generally added to the contract agreement that is made between the university and the industry concering contract research. The cost of ownership of the IPR will generally come at a cost that exceeds the full cost of generating the IPR.

***Licensing***

The effectiveness of licensing was difficult to compare as different universities have different methods for measuring the effectiveness of the license. Stellenbosch University, and various others measure it by the number of licenses currently active at Stellenbosch University. KU Leuven measures the licensing agreements by the capital that has been generated through the licenses, which is around 118 million Euros.

# Chapter 10

# Discussion

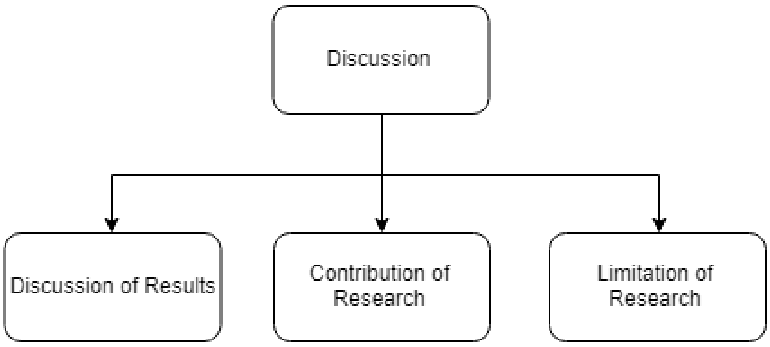


**Figure 10.1:** Overview of Chapter 10

- Section 10.1 – Discussion of Results: Discusses how the conceptual framework helps to systematically compare "knowledge dissemination practices" from different universities, but also gives insight into the environments in which the universities operate.
- Section 10.2 – Contribution of Research: This section aims to discuss how the framework can be implemented into practice.
- Section 10.3 – Limitations of Study: The limitations of the study are stated here as these factors need to be considered when interpreting the results.

## 10.1 Discussion of Results

This section discusses the results of the framework. The first section discusses, in theory, how it is expected for each of the concepts to function is a developed or developing country. The second section focuses comparing the results of the case studies to that of theory to present how these concepts function in practice.

### 10.1.1 In Terms of Conceptual Framework

***Goals of the University***

The goals of a university should dictate every action taken by every entity in the institution. These goals are to be clearly stated in the mission statement, although the mission statement is a general statement of no more than a paragraph. The university bases its objective and the key performance indicators on the environment in which it is located.

Whether the university is situated in a developed or developing country will determine quite a significant number of factors. These include financial stability, percentage of highly educated populous, developed industries and developed technologies. Developed countries generally have access to more funds, giving the opportunity for larger grants from the government. If the government does not allocate enough money through grants to the university, there is a well-developed industry from which the university can also receive funding. Universities situated in developing countries generally receive less money from governments, and the industries are generally not as well developed. Industries in developing countries, generally, buy their core technologies from companies situated in developed nations, and refrain from developing their own core technologies. This means that industries are more reluctant to invest in R&D projects that are more theoretically based and done at the university.

The size of the university also plays a role. This gives the university a larger pool of students to choose from for research projects. The flow through of students is one of the advantages that a university has over a regular research institutions, as it allows a constant flow of new people with new ideas that can be utilised. Undergraduate students are important to a university, but they generally do not contribute to the research output of a university. A university that has a larger percentage of post graduate students has more resources available to it for research and development.

***Intellectual Capital***

Effective knowledge dissemination is based on the management of the intellectual capital of the university, and IPR forms a very small portion of this. As was discussed in Section 7.4, the university has three types of Intellectual Capital: (1) Human Capital, (2) Organisational Capital and (3) Social Capital.

The managing of human capital in a university is extremely important. A well-known researcher is quite valuable to a university based on the publications they produce in their field of research. Universities therefore must manage their researchers to best suit the environment in which it is placed. Developed countries would like to maintain their expert researchers, as their research in new fields of study are extremely valuable. Although developing countries still have research experts in their respective fields that are far fewer than those found in developed nations due to the nature of a developing country. Developing countries might want to encourage researchers to pursue a new business in industry rather than retaining them as a researcher.

Organisational capital is the physical information that can be transferred. This must be disseminated in the most effective method, which would be highly dependent on the incentives that are in place concerning knowledge dissemination.

Finally, social capital is an element that every university would like to improve. There is, however, three communities in which social capital is important and that is the international community, national community and regional community.

These three types of intellectual capital elements each contribute to the knowledge dissemination. Organisational Capital is the knowledge that must be disseminated. Human capital generates the knowledge and Social Capital acts as a marketing tool.

***Intellectual Property Rights***

IPR is the protection of the innovative creations that was generated, and this is especially important in a university setting. Copyright is the most used intellectual property right, as it is protected without any registration required. When looking at patents and plant breeders' rights, however, it becomes a bit different. Registering these IPR's in industry is not expensive, as they are protecting their core business, making the costs insignificant. In a university setting, however, protection of a creative innovation is debatable.

Universities situated in developed countries should focus on protecting technology that can be commercialised. In developing countries, however, the protection of technologies should be limited to those that have been developed to a point where it can be sold to industry. IPR registration costs in a university setting, especially in a developing country, can be significant enough to be over a third of the capital that has been allocated to the entire research project.

***Funding***

Funding plays an important role in research. As was discussed in Section 5.1, the capital invested in R&D can rarely be reclaimed as the investment was not in assets but mostly in the salaries of the researchers. As most of the work conducted by the university is research related, the university requires significant funding for all the researchers.

This study, however, focuses on the funding available for investing in spin-off companies from research teams in the university. The capital available for this will be dependent on the funding that is available to the rest of the university. In this case, universities located in developed countries have more capital available to invest in these companies than those located in developing countries. The focus is not so much on the size of these funds, but rather what strategies are employed to increase these funds for the future. Universities in developed countries can allocate less of the income from successful technology transfer to the university, but universities in developing countries needs that additional income for normal operation.

***Incentives***

Researchers have 3 forms of incentives for producing noteworthy research; (1) the joy of overcoming a challenge, (2) reward or recognition and (3) monetary rewards. The joys or overcoming a challenge is a personality trait, and rewards and recognition can only be used so often, or else they lose their appeal. If everyone receives a reward, it does not commend anyone specifically on services rendered. Recognition in the scientific community is difficult to obtain, but it is done through hard work, and numerous publications.

An incentive that can be used in every situation is monetary incentives. Incentives for publications are difficult to analyse, as they are sometimes not constant in the same university. The incentives for spin-off companies, research contracts, consultations and licensing, however, are drawn up in the university's IP policy. It is interesting that the percentage of income to the inventor (monetary incentive) for all these items are similar in universities located in both developed and developing countries. Although, it was expected that universities in developed countries would give a larger share of the income from technologies to their researchers, as they have more capital to fund other areas of the university, this tended not to be true. They all tended to give the inventor around 33% of the income generated. Sometimes this would be a bit more, and sometimes bit less. Consultations are also the same in both environments, which is that the university only requires compensation for the hours worked, and the equipment used.

Finally, in terms of incentives to industries, this also remains constant. With the university not taking a portion of the researcher's income from consultation, the industry would pay less for the consultation. In terms of research contracts with the university, the industrial partner must cover the direct cost, which generally results in the industry receiving more research than it would have gotten with internal research.

***Infrastructure***

The infrastructure in this study refers to the policy infrastructure of both the institution and the country. The country's policy focuses on specifically on the IPR of research conducted with nationally funded resources. As the laws, situations and environments constantly change to small details, comparing the policies will not be helpful as they are a result of numerous different elements. Therefore, only the published and revision date was used.

The publication date provided an indication of the length of time that the university has been focused on selling research to industry. It was expected that the publication date in a developed county should be further in the past that that of a developing country. This is due to the proximity to developed industry. Industries in developing countries do not generally have such a high focus on R&D.

The revision dates are also important as the indicate the willingness of the institution to change their policies based on the changes that happens. Frequent revisions would be best for universities, but it is expected that universities in developed countries would be able to do this, and not those situated in developing countries. This is due to the availability of resources.

***Info-Structure***

The section is on the available resources allocated to ensuring that technologies succeed in the market place. For this study the focus is on incubation centres that spin-off companies uses when the companies initially start out.

New companies generally take time to develop into a self-sustaining company, especially if they are based on new innovative ideas that still needs to be tested. Universities in developed countries can afford to support these companies for an extended time. University in developing countries must focus on throughput. A company must become self-sustaining quickly, so that a new company can take its place.

***Info-Culture***

The cultural differences between industry and university researchers presents a difficult problem for the TTO. They must manage different motives, from different entities. Different motives can result in friction between the entities, but if well managed, both parties can get the outcome they desire, with very little compromise.

TTO's function as the central point of communication between the researchers and industry. If a researcher would like to commercialise his/her research, they would approach the TTO to market it to industry, and industry would approach the TTO if they require a research team. This is the basic function of a TTO, and in a university located in a developing country, with limited resources, this would be the extend of its function. TTOs of universities in developed countries can increase its effectiveness by employing further resources to coordinate research groups in a university.

***Dissemination***

The effectiveness of the dissemination of knowledge is dependent on the goals of the university. It is therefore difficult to compare the number of publications, spin-offs and licensing agreements of the two primary case studies as they are in different backgrounds. The secondary case studies make a helpful comparison, as they can present the outcomes of a university based on other universities in similar environments.

### 10.1.2 In Terms of the Case Studies

***Goals of the University***

KU Leuven is situated in developed country, situated in the heart of Europe. It has access to substantial funding and receives the more funding from government than any other university in Belgium. It has over 45,000 students of which 51% of them are postgraduate. KU Leaven is a university that utilises all the benefits of being in a developed nation. It should be noted, however, that there are no student fees in Belgium, so KU Leuven does not have access to that form of income. The costs for the students are carried by the government.

Stellenbosch University is in a developing country with limited funds. It houses just over 23,000 students, of which 28% are postgraduate students. Stellenbosch, although still receiving grants from the government, is not one of the universities that receive the most (Citizen Reporter, 2018; Stellenbosch University Administration, 2018).

***Intellectual Capital***

Human Capital is the main source of research generation for a university. In a developed country, the universities aim to build up experts in different fields. When looking at KU Leuven's policy on new spin-off companies, it encourages the researcher to nominate postgraduate students that worked in the research project to run the new spin-off company. This would ensure that the university maintains its expert and the new companies are run by individuals that are competent. At Stellenbosch, the opportunity to found a company is with the research group leader. This would mean that the research group leader would leave the employ of the university, increasing the knowledge capacity of the

South African industry and opening a position at the university, creating an opportunity for fresh ideas in the research group.

The organisational capital in both primary case studies are disseminated through publications. It is, however, important to not the priority of timing of these publications, and this relates back to how governments allocate grants to universities. In the KU Leuven case study, grants are allocated based on both the number of publications and the number of citations. As government funding is the largest portion of the university's income. If a researcher has discovered a new concept, the university encourages the researcher to publish the article, and find other ways of protecting and selling the idea. As the status of first discovery is more important than ownership of a technology.

In South Africa, grants are allocated based on number of publications only. This allows the university to retain the publication, until the patent is filed, and the technology is in such a position as it can be marketed to industry.

Finally, social capital is the prestige of a university, which can be based on its regional and international ranking. Prestige in the international community is important, and developed nations often rank their universities according to the ranking indices used by the international community. Developed countries develop their indices based on the need of the country as is money is limited. This makes university rankings in a developing county confusing, such as is the case with Stellenbosch University, as local rankings scores the university at fifth in the country, but International Ranking, such as QS University Ranking ranks the university at third (Quacquaelli Symonds, 2017; Staff Writer, 2018).

***Intellectual Property Rights***

Regarding IPR in the different institutions, KU Leuven has numerous technologies that have been patented, but is still begin advertised to industry for a potential market. This signifies that KU Leuven will patent a technology that shows promise in the market place.

During an interview discussion it was explained how reluctantly universities in South Africa patent technologies. This is due to the cost implications. In a developing country setting, it is more important to spend money on developing and marketing a technology, than it is to protect it.

***Funding***

Both Stellenbosch and KU Leuven have moved beyond the equal division of income between the university, inventor and innovation fund. Both of their policies also stipulate a change of this ratio when passing a certain point, decreasing the percentage allocated to the inventor and university and increasing the percentage allocated to the innovation fund. This means that the inventor will still be rewarded, but most of the income will be invested in future project. KU Leuven has 4 tiers depending on the size of the innovation, and Stellenbosch has only two, with the highest tier still being situated in first tier of KU Leuven. This just gives an indication of the size difference of technologies that has been developed through KU Leuven and though Stellenbosch University.

***Incentive***

Monetary incentives to the inventors are quite standard in both cases. KU Leuven reduces the percentage allocated to the university and increase the percentage allocated to the innovation fund. Stellenbosch University, however, uses an interesting strategy to increase incentives for creating technologies. Allocating a portion of the income to the inventor acts as a pull incentive.

In the division of income, the money from the technology is not allocated to the TTO or to the university administration. It is divided between the research group and the faculty. This encourages the faculty and research groups to be actively searching for innovations that can be commercialised, as the money will go towards funding their own faculty and research group. This acts as a "Pushing" incentive.

***Infrastructure***

When it comes to policy implementation, both Stellenbosch University and KU Leuven were the leaders in their respective environments. Stellenbosch was the first to implement a IP Policy for commercialisation at a university in South Africa, and KU Leuven was the first in Belgium. However, unlike KU Leuven's policy that is regularly updated, Stellenbosch University's Policy has not recently received a revision. This is even after the South African policy has been revised.

***Info-Structure***

As KU Leuven has more funds available, it can support 3 incubator centres, whereas Stellenbosch only has a single incubator centre. Unlike Stellenbosch University, KU Leuven does not set a deadline for the spin-off to become a sustainable business. It focuses more on developing the spin-off company to produce a sustainable business. A business plan must be submitted, and it is reviewed every 6 months to see how the business has developed, and where it is heading.

***Info-Culture***

InnovUS, from Stellenbosch University, focuses on just fulfilling the basic functions of a TTO. It has a staff of around 20 people. LRD, from KU Leuven has more than 140 people. This allows them to reach out to research groups, discussing current research projects and linking research groups from different departments that are researching similar subjects. As they are actively involved with the research conducted in the different research groups, they can also more effectively market potential research contracts to industries. This is also used to link research groups in the university together.

## 10.2 Contribution of Research

The dissemination of knowledge from a university to industry generally passes through the TTO. There are numerous studies, as was discussed in Section 2.2, that focus on effective methods of technology transfer from the TTO. Most of these studies are, however, focused on a specific environment in which the university operates. Some studies are only done on universities situated in developed or developing nations. Some of the studies are done on only universities which are located in Europe. All these models, frameworks and studies aim to identify the variables that would determine effective technology transfer or knowledge dissemination for a specific environment.

This research study developed a conceptual framework that aims to analyse the impact that the environments have on the management of knowledge dissemination. The framework incorporates the elements that influence the flow of intellectual capital into society, and the control elements that the university uses, namely the TTO. The knowledge dissemination of the university should always be inline with the mission of the university, which is influenced by the environment in which it is located and the goals that it is aiming to achieve. Any action taken to disseminate knowledge that does not align with the goals of the university, cannot be deemed as effective.

The framework allows universities to systematically evaluate their knowledge dissemination practices in comparison with other universities. The specific contribution of the framework is its ability to also clearly describe the environment within which a university is operating insofar as it may impact the implementation of different practices and strategies. This ability also provides a platform for researchers to evaluate the practices at universities to improve our understanding of which practices drive improved results under different circumstances.

The results from the case study clearly shows the ability of the framework to facilitate the systematic comparison of the knowledge dissemination practices at different universities. This includes providing a clear appreciation of the realities in different environments in which these universities operate. The case studies also provide an opportunity to illustrate how the framework might be used to test hypotheses regarding how universities respond to the environments within which they operate.

## 10.3 Limitations of Research

For this study, numerous assumptions had to be made. These assumptions placed boundaries on the study, but it also created some limitations. The following two sections discusses these limitations. The first section discusses the limitations in terms of the conceptual framework, and the other section discusses the limitations of the case studies that were selected.

### 10.3.1 In Terms of Conceptional Framework

This study focused exclusively on public universities. Public universities are mostly funded through government subsidy, and only use the selling of research as an additional source of income. The study does not specifically consider private universities. Private universities receive little or no funding from the government, so their main sources of income is through the selling of research and through student fees. Private universities can generally be expected to have a strong reliance on funds received from industries.

Universities can also derive income from additional sources, that are not mentioned in this study. One example can be found in the donation of funds from industry or individuals to the university. Such donations, especially when provided by industry, may be given under certain terms and conditions. Some agreements, for example, will include non-exclusive licenses for IPR that are produced from the research areas that are funded. One example of this can be found in a case study by Fleming and Davis (2007), concerning funding that was given by Hewlett-Packard to California NanoSystems Institute. This case study was conducted on the mis-communication between the entities, but both entities knew that some advantages were to be given to Hewlett-Packard concerning the licensing of technologies. In this case they were given non-exclusive license to technologies they identified as "part of their business".

Other donations, such as the Structural Genomics Consortium stipulate that all the results of the medical research conducted by means of these funds are to be published as public research. These different conditions imposed through donations to universities make it a difficult source of funding to evaluate, which is the reason it was excluded from the scope of this study. Future work could endeavour to also include these funding streams.

Research subsidies in individual countries are assigned by means of an index used by the government to determine the amount of funding to be assigned to each university. These universities generally use indices that are aligned with these indices to assign funding between their departments. Each department can then assign the funds in their own way, and it is divided between the researcher and the research group. As every department can individually assign the funds between the researchers and the research groups, it was not possible to determine the effect of differences in incentives on the exploiting of research and publishing at the individual researcher level as each department creates its own policies.

Furthermore, it is worth mentioning that the present study focused primarily on a single university in two counties. It would be interesting to see how higher ranked universities in South Africa and lower ranked universities in Belgium exploit the research that is conducted at these institutions.

One of the major shortcomings of the research is that it focuses on universities on a macro level. Acquiring data for universities at a micro level is difficult as the risk of acquiring confidential information would be high. This is also one of the major shortcomings that is found in most of the research discussed in Section 2.2. The availability of data was a concern as well. Some universities do not publish their data as openly as others. Originally, more case studies were selected as secondary case studies, but due to a lack of data, they had to be removed from the study.

Finally, the only validation of the framework based on the feedback given from the experts in the field and the implementation into the case studies. The framework will require additional validation in the future, before it can be implemented. The feedback that was received on the current framework is very subjective.

### 10.3.2 In Terms of Case Studies

The study only uses 2 primary case studies, each located in its own environment. This lack of data availability might prove problematic, but the purpose of the case studies is to showcase the systematic approach of using the framework. Both the primary and secondary case studies that were selected were higher education universities. These entities are more comparable as they focus on both applied and basic research. Entities such as private research centres and universities of technology were excluded as they focus predominately on applied research.

The case studies are limited to 2 successful primary case studies in their respective environments. This limits the study as only one method for operating in each of these environments is highlighted. There might be different methods that can be employed, which are not highlighted by the study, as there are no case studies for this.

Another limitation is that the universities located in the United States of America are excluded. They could provide some interesting additional insights, as some of the universities that are ranked in the top 10 of the world, are private universities located in the United States of America. They will have policies in place that can maximise income from the selling of research, and still have an effective knowledge dissemination system.

Finally, using South Africa as a developing nation might be misleading. South Africa, although classified as a developing nation by the United Nations has infrastructure available to them that will not be found in other developing nations. Some of the cities located in the county are very modern, and there are numerous investment opportunities in the country. The country does, however, still suffer from poverty and lack of utilities for all citizens. Although South Africa has some universities that are ranked relatively high, there is still a large portion of the country for which educational outcomes is relatively poor. This is important to note, as South Africa might be ranked as a developing nation, but some areas will have access to infrastructure that is found in first world countries. This might make it difficult to compare South Africa to other developing countries.

# Chapter 11

# Conclusion

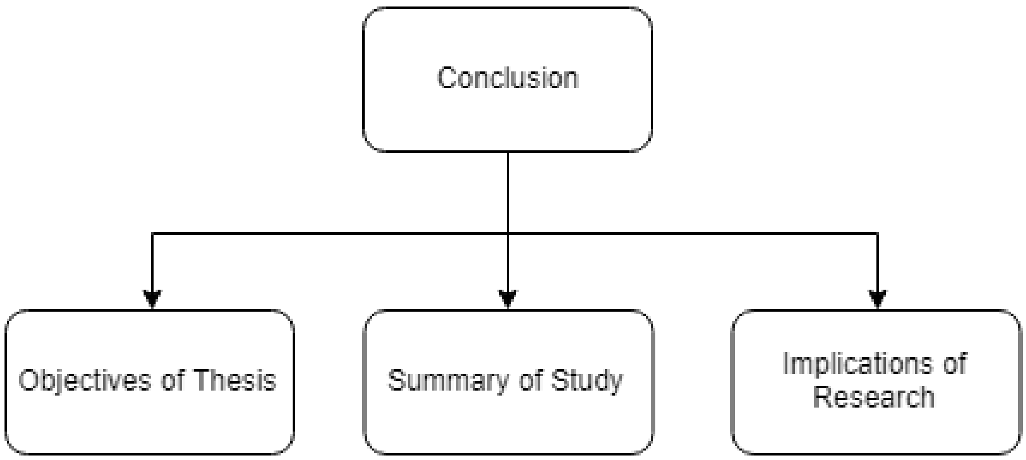


**Figure 11.1:** Overview of Chapter 11

KU Leuven and Stellenbosch University have some of the most matured Technology Transfer Offices in their respective countries. Evaluating how they manage their TTOs provides some insight regarding the different challenges and considerations that are at play in different environments. This thus contributes toward a better understanding of how TTOs operate and how universities respond to different environmental factors. This serves to inform other university TTOs regarding best practices in these environments and provides policy makers with better understanding regarding how TTOs are likely to respond different.

The previous five chapters aimed to highlight the important concepts with respect to knowledge dissemination from universities. This final chapter aims to give a summary of the work that was completed in this research project.

- Section 11.1 – Objectives of Thesis: This section states the objectives that were listed in Section 1.3 and links these objectives to the chapters and material that aimed to meet these objectives.
- Section 11.2 – Summary of the Study: The aim of this section is to identify what each chapter in the report aimed to achieve.
- Section 11.3 – Implication of Research: This section mentions three of the main factors that impact effective knowledge dissemination, namely, availability of funds, incentives and an effective TTO.

## 11.1 Objectives of Thesis

The objectives for the research project were identifies and stated in Section 1.3. These objectives are listed below along with the chapter in which they were achieved and how they were achieved.

1. Critically review and analyse methods of exploiting Intellectual Property Rights (IPR's) - Chapter 4 presented a comprehensive literature review in which the exploitation of IPR was discussed.
2. Critically review and analyse the economics of intellectual property and innovation - Chapter 5 summarises in the literature review the impact that intellectual property and innovation has on the economy of a county, private entity and research entity.
3. Critically review and analyse industry-university linkages and impacting factors - Chapter 6 identified the characteristics that are associated with collaboration between industry and universities.
4. Critically review current models for effective knowledge dissemination - Section 2.2 identifies knowledge dissemination models that have been used to monitor the the dissemination of knowledge into industry.
5. Construct a conceptual framework, identifying the best practices for the dissemination of knowledge from universities - Chapter 7 and 8 states the steps that were done to build the conceptual framework, along with the concepts that were identified.
6. Perform an empirical study evaluating the implementation of the exploitation of intellectual property and the link between the exploitation of IPRs and the dissemination of knowledge - Chapter 9 and 10 discusses linkages between the exploitation of intellectual property and dissemination of knowledge in both developed and developing counties.

## 11.2 Summary of the Study

The section will provide the an overview and summary of what was accomplished in each of the chapters presented in this study.

- Chapter 1 presents the goals of the study. The chapter aims to give a brief overview of the research area along with the research aim of the study. In Chapter 1 the objectives for the study were set, and the study was divided in to three parts, (1) construction of the conceptual framework, (2) data collection and analysing results and (3) conclusion.
- Chapter 2 discusses the previous studies done on the topic, and how this study aims to fill the gaps in literature.
- Chapter 3 discussed the research methodology that were followed in the study. The study followed a qualitative research methodology, and the steps that were taken are to ensure that the results that are presented are reliable are presented in this Chapter.
- Chapter 4, 5 and 6 presents literature review, and forms the first part of the conceptual framework. The literature presented in the literature review was used to identify the concepts that were used for the construction of the the conceptual framework.
- Chapter 7 and 8 presents the construction of the conceptual framework, in which all the concepts are highlighted that impact the knowledge dissemination from universities. The chapter also identifies methods for measuring these concepts and whether these variables can be considered as independent or dependent variables for the purpose of the study.
- Chapter 9 is concerned with data collection. This section identifies the two main cases, Stellenbosch University and KU Leuven, and compares these universities to other cases to identify the performance of the universities. This is used to identify how the universities are performing relative universities located in similar environments and which environments are producing similar universities.
- The analysis of the data is done in Chapter 10 with the construction of an analysis framework. The framework states the expected state for each of the concepts that were identified in the conceptual model, and how they influence knowledge dissemination in a developed and developing country. The same model is then used to implement the data from the case studies to evaluate the correlation between the theory and practice.

## 11.3 Implications of Research

Through the analysis framework that is presented in Chapter 6, a few critical factors were identify that influence the knowledge dissemination from universities. The availability of funds is the first factor that influences how a university influences the effective knowledge dissemination from universities. The funds appear to determine policies on investments in technologies and spin-off companies. The availability of funds will also determine the compulsory funds that are required by the university, which will limit the university's ability to create incentives.

The second factor that influences the knowledge dissemination is incentives, which includes the incentives from the government and the incentives from the university to create innovations. If governments subsidies and grants are allocated to universities based on the h-index of the institute, universities will create incentives to increase basic research. If governments assign subsidies and grants that are not influenced by the h-factor, universities will create more incentives for applied research, as this can be published and licensed out, creating a double source of income.

The final important factor that will be mentioned here is the importance of having an effective TTO. The TTO manages the interaction between the research done at the university, and the technologies that are required by the industry. The effectiveness of the TTO will determine the effectiveness of knowledge dissemination to industries. The TTO plays a major role in the linkages between university and industry.

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# Appendices

# Appendix A

# Intellectual Property Rights

## A.1 Patents

The basic criteria for a patent is the following: "patents are granted for new, non-obvious industrial inventions, and give the patent owner the right to exclude others from producing, selling or using the technology in that specific country" (Cetindamar *et al.*, 2010; Knight, 2001; Hsu, 1996; Shah *et al.*, 2013). Even though the laws differs from country to country with respect to different aspects of the law, this is still used as the definition for patentable inventions by most countries and in most literature.

The patent is an agreement between the inventor and the government of the country to give the owner exclusive rights to the technology while it is valid, and when it expires the patent will become public knowledge. A patent can expire if the maintenance fees are not paid, or if the term of the patent expires. The term of protection for a patent is usually 20 years (Knight, 2001; Shah *et al.*, 2013; Hsu, 1996).

Patents do not give the holder the right to produce, sell, or use the invention, but rather to exclude others from doing so. Some patents are filed for technologies that require other technologies protected by other patents to in order function (Knight, 2001; Shah *et al.*, 2013; Hsu, 1996).

A simple example of this is in the pharmaceutical industry. A pharmaceutical company develops molecule "C", which consists of an improvement on molecule "A" and with an addition of a derivative of molecule "B". The company can file for a patent on molecule "C" and it will be granted as it is a "new non-obvious industrial invention". However, the company can only use, produce and sell molecule "C", if the company has the right to use, produce and sell molecule "A" and "B". The company can, therefore, only exclude others from using, producing, or selling molecule "C".

This is a simple case in which only the rights to three patents needs to be obtained. Some technologies today requires thousands of smaller technologies, most having their own set of patents, to function. Prasad *et al.* (2006) performed a case study on the Format war between HD-DVD and Blu-Ray. In it, it was observed that about 83 000 essential patents were required to allow a Blu-Ray disk to function, and they were owned between 25 major players, and many other smaller companies.

The filing of the application is usually done by a patent attorney, but there are no legal restrictions on who has to file the patent in most jurisdictions. Filing for a patent is a very tedious process, and many mistakes can be made. If a patent is stated incorrectly, the patent can fail to protect the invention, infringe on another patent, or state the patent so that it is no longer a new invention. It is, therefore, better to make use of a professional in the field, since they know how the system works, and how to phrase the terms so that the patent accurately describes the invention (Knight, 2001; Hsu, 1996).

In general, when a patent is registered, the applicant will see a patent attorney. The applicant will explain the technology to the attorney, and the attorney will describe the technology in the patent application. The claims of the patent will, firstly, be stated as broadly as possible. A broader claim will allow the owner a wider range over which the patent is valid, and hopefully be vague enough that competitors will not be able to produce the technology from the patent alone. This will reduce the likelihood of them infringing on other patents, giving them more freedom to develop the technology, as well as being able to charge licence fees to companies who are producing products similar to their own. When the patent is examined, the examiner will determine: which claims are valid, which claims need to be made more specific and which claims infringe on another patent, or is prior knowledge. Most applicants aims to apply for a very broad, and non-specific patent, as this increases their freedom to operate. This usually results in patents being evaluated multiple times (Belderbos *et al.*, 2014).

There are major differences between patent systems in different countries - from what happens to a patent when it is filed to when it is granted. All countries, however, disclose the patent to the public regardless of whether the patent has been granted, rejected, or is still pending after a certain period of time. This period is usually 18 months. Therefore, 18 months after a company has filed a patent, all their competitors will know what technology they are developing (Knight, 2001; Hsu, 1996).

Infringement enforcement is an important part of the intellectual property industry because without this, patents would have little meaning. There are multiple types of infringements, the most obvious being direct infringement. This is the making, selling or use of a product that is the exact copy of an invention or something that has never been made before, but that is stated in a patent. Contributory infringement is committed when someone manufactures a product which is specifically designed to be used by others in an infringing manner. The third type of infringement is induced infringement which is committed when knowingly or unknowingly, a company or person encourages another person or company to do something that infringes on another's product. The final form of infringement is importing a technology without the express permission of the patent holder in the country where the technology is developed (Knight, 2001).

Infringing a product or process results in fines to repay all the damages that were done during the time of infringement. When infringement occurs, the company who's patent is being infringed on must take the infringing company to court. No action will be taken against an infringer unless the owner of the patent initiates it. When a company takes another company to court, the plaintiff will accuse the defendant of infringement. The defendant, on the other hand, will try to invalidate the patent that they are infringing on, by trying to find any previous art that the patent uses, and using that to prove that the patent is not novel (Knight, 2001).

Patents are not granted on the same standard in all countries. In the European Union, a patent is filed, and then the applicant has a certain period in which to request an examination. An infringement claim cannot be filed unless the patent has been granted by the patent office. In the United States of America, a patent is granted after a short examination, and only examined in full when an infringement claim is made, either by the company or against the company.

There are various reasons why the differences exist. By having a shorter examination period, the patent is granted earlier. This allows the owner to immediately claim damages from people who infringe on the patent. It also allows the owner to make use of licences earlier in the life of the patent. These patents have less value than those that are properly examined before being granted, since the owner is not sure if it will pass examination when filing an infringing or reclaiming damages case. Responsibility is on the owner to study prior state of art, before the patent is filed to be sure of the value of the patent (Knight, 2001).

Another important concept of patents is that they are only valid in the country in which they are registered. If a patent is not registered in a country, the owner cannot do anything to an infringer in that country. The registration costs and maintenance fees of patents can add up to a substantial amount.

The registration fees of a patent are fixed, but the cost of hiring legal help should also be included. A patent has to be renewed every few years, which is referred to as the maintenance fees of a patent. The maintenance fees increase exponentially over the duration of the patent.

The cost of patents is the limiting factor in the amount of countries that they are registered in. It is, however, important to note that it is not necessary to file the patent in every country. It only needs to be filed in the main manufacturing and customer countries. If the invention is protected in these countries, infringing companies will be less likely to rise in other countries. The countries in which patents are mainly filed are the United States of America, the United Kingdom, Germany, France, Japan and China (Knight, 2001; Bhat, 1996; Hsu, 1996).

There are international treaties in place that assist an inventor with filing in different countries. According to the Paris Convention for the Protection of Industrial Property, or often referred to as the the Paris Convention, an inventor has one year to file a patent in additional countries after the patent has been filed in the first country. This gives the inventor time to research where the patent will be most valuable and in which countries it will not be necessary to file in. It also allows the company time to research the commercial potential of the patent. After a year, the invention is not novel any more, and the patent cannot be filed anywhere else (Knight, 2001).

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) is the first agreement that related intellectual property rights to trade agreements. This agreement was made in order to ensure that all countries conform to minimum requirements for intellectual property rights, both in legislation and in enforcement. TRIPS allows companies to be more confident when they file for patents in other countries, enabling them to know the patents will be enforced and the agreement honoured. (Knight, 2001; Drahos, 1997; Shah *et al.*, 2013; Dinopoulos and Segerstrom, 2010; Naghavi, 2007; Ivus, 2015).

The Patent Cooperation Treaty (PCT) was established in 1970, and is the system used to file patents internationally. Most countries that are part of the Paris Convention also form part of the PCT. The PCT has both advantages and disadvantages, stemming from the attempt to streamline the international patent process. The advantages of this treaty are as follows (Knight, 2001):

1. Provides a convenient mechanism for filing patent applications in multiple countries.

2. Payment for filing, translation and other fees can be deferred for up to 30 months.

3. International searches for similar patents are done within 3 months of receipt or 9 months from the priority date.

4. Applicants can file in almost every country for one fee and then decrease the number of countries later on without additional costs.

5. Applications filed via PCT are published 18 months after priority dates.

The disadvantages:

1. Using PCT to file patents increases the total global billing, which is especially relevant when the patent is only filed in a few countries.

2. The application is not examined for at least 20 months, which is too long if the applicant is trying to stop infringement at the time of filing.

3. PCT invites indecision, since there are so many options available, there is a tendency to to put off deciding in which country to file.

Applicants file at both the Paris Convention and the PCT since they both fulfil different roles. The Paris Convention establishes the priority date for the patent and the PCT is the actual filing mechanism for filing patents internationally (Knight, 2001).

## A.2 Plant Breeder's Rights

Plant breeder's rights are very similar to that of patents. The main reason for this is because many religions and beliefs do not support the idea of owning a living organism, but as plants form such a large part of the economy, they are not something that can be left unprotected. Companies operating in the agriculture industry, such as the timber, food or cotton industry, invests millions in breeding plants that can grow at a higher rate, produce a higher yield and are immune to specific pests. However, very few authors deal with plant breeder's rights, as most managing principles are the same as patents. Albert II (2011) and The Republic of South Africa (1976) will be used to define the plant breeder's rights.

Patents, in most countries, cannot be filed for a living organism, and so the answer to protecting the agriculture industry is plant breeder's rights. There are some key differences between patents and plant breeder's rights which make them more acceptable to the public (Albert II, 2011; The Republic of South Africa, 1976).

A plant breeder's right is given for any variety of plant generation and species that is new, distinct and stable (Albert II, 2011; The Republic of South Africa, 1976).

- "New" indicates that propagating material or harvested material has not been sold or otherwise disposed of by, or with the consent of, the breeder for the purposes of exploitation of the variety before the date of filing of the application for a plant breeder's right.
- Distinct implies that it is clearly distinguishable from any other variety whose existence is a matter of common knowledge at the time of the filing of the application.
- Stable, if the characteristics thereof remain unchanged after repeated propagation or, in the case of a particular cycle of propagation, at the end of each such cycle.

One of the main reasons that plant breeder's rights are accepted in countries is that they generally only applied to commercial uses. Private and non-commercial uses are excluded from the protection. This allows people to grow any plants at home, both for food and aesthetic reasons. The plants that are excluded from protection under the plant breeder's rights are plants that are used to breed other varieties and any fungi or algae (Albert II, 2011; The Republic of South Africa, 1976).

Plant breeder's rights, unlike patents, also adjust the term of the plant breeder's rights, depending on the type of plant for which it is filed. It can be valid for twenty, twenty-five or thirty years. This ensures that the breeder actually receives compensation for the work done. If the protection expires before the breeder has actually made a profit from the plant, due of the long growth period, there would not really be any need to file for a plant breeder's right (Albert II, 2011; The Republic of South Africa, 1976).

Another difference to patents is that the priority date for plant breeder's rights is set on the day that the breeder receives the certificate of registration. A patent's priority dates are set to the day that it is filed, regardless of when it was approved (Albert II, 2011; The Republic of South Africa, 1976).

Plant breeder's rights give the breeder the right to do the following, but only in the country of registration:

- The production or reproduction (multiplication) for the protected variety.
- The conditioning for the purposes of propagating the protected variety.

- The sale or any other form of marketing of the protected variety.
- The exporting or importing of protected variety.
- The stocking of the protected variety for any of the above purposes.

## A.3 Copyright

Copyright is broader than any of the other intellectual property fields. Copyright can be filed for any expressible form of a creative idea. These creative ideas can be expressed in the following ways, as is stated and defined by The Republic of South Africa (2002):

1. Literary work includes, irrespective of what mode or form it is expressed in:
    a) Novels, stories and poetic works
    b) Dramatic works, stage directions, cinematograph film scenarios and broadcasting scripts
    c) Textbooks, treatises, histories, biographies, essays and articles
    d) Encyclopaedias and dictionaries
    e) Letters, reports and memoranda
    f) Lectures, speeches and sermons
    g) Tables and compilations, including tables and compilations of data stored or embodied in a computer or a medium used in conjunction with a computer, but shall not include a computer program
2. Musical works include any work consisting of music, but it excludes any words or action intended to be sung, spoken or performed with the music. This is included under literary works
3. Artistic works:
    a) Paintings, sculptures, drawings, engravings and photographs
    b) Works of architecture, being either buildings or models of buildings
    c) Works of craftsmanship not mentioned above.
4. Cinematograph films includes any fixation or storage by any means whatsoever on film or any other material of data, signals or a sequence of images capable, when used in conjunction with any other mechanical, electronic or other device, of being seen as a moving picture and of reproduction, and includes the sounds embodied in a sound-track associated with the film, but does not include a computer program;

5. Sound recordings includes any fixation or storage of sounds, or data or signals representing sounds, capable of being reproduced, but does not include a sound-track associated with a cinematograph film.

6. Broadcasts are defined as the telecommunication service of transmissions consisting of sounds, images, signs or signals which:

   a) Takes place by means of electromagnetic waves of frequencies of lower than 3000 GHz in space without an artificial conductor.

   b) Intended for reception by the public or sections of the public and includes the emitting of programme-carrying signals to a satellite.

7. Programme-carrying signal embodies a program which is emitted and passed through a satellite.

8. Published editions are the first print by whatever process of a particular typographical arrangement of a literary or musical work.

9. Computer programs includes a set of instructions fixed or stored in any manner and which, when used directly or indirectly in a computer, directs its operation to bring about a result.

Copyright includes a wide range of innovative creations. Some of the main occupations who's work is protected by copyright are: all types of artists, academic findings, programmers, writers, and film makers. Copyright is valid from the moment it is produced. The period of time in which copyright is valid differs greatly depending on the type of copyright and country. To give some examples: literary works and artistic works are generally valid for the entire duration of the author/artist's life and a few years after the death of the author/artists. Broadcasts, on the other hand, are valid for a specified term that begins the day of the first broadcast. The period of time that the copyright is valid for also differs greatly depending on the country. In South Africa, the copyright on literary, musical and artistic work is valid for 50 years after the death of the author. In Belgium, the term is 70 years after the death of the author (The Republic of South Africa, 2002; The Belgium Federal Government, 1995).

There is also no registration required for copyright. The only requirement for the copyright to be valid is for the author to produce proof of how and when he/she produced the material. If he/she is able to prove that he/she produced the intellectual property first, ownership will be assigned accordingly (The Republic of South Africa, 2002).

Copyright is always assigned to the author/artist, although the ownership is generally transferable, which was not always the case. In the past, copyright always belonged to the author. This presented problems, specifically in the software industry. A software company can hire a programmer to write code for them, but the program still belongs to the programmer and not to the company. When this was realised, the law was modified because companies would not lose their investment if a programmer decided to leave. All software companies have a contract with their employees that transfers all copyrights to the company automatically in such an event. The name of the author is always attached to the item that is copyrighted giving, credit to the author (Cetindamar *et al.*, 2010; The Republic of South Africa, 2002).

## A.4 Trademarks

A trademark is a distinctive mark that distinguishes the products or services of different businesses. Trademarks can be made up of a combination of letters, numbers, images, sounds, containers for goods, colours, shapes, and patterns. Trademarks are better protected if they are created from made up words, and not words that directly describe the service or the product that they represents.

Trademarks are valid for 10 years after registration, but they are different to other IPRs in two ways. Firstly, trademarks can be renewed. Therefore, a company's trademark can essentially exist for a very long time. Secondly, a trademark can be made public knowledge if the owner does not use the trademark for a long period of time. Other IPRs will remain the property of the owner until they expire (The Republic of South Africa, 1997).

Trademarks also give the owner the right to exclude others from using the sign. This allows an entity to build a reputation or brand and stop others from influencing that reputation in a negative way. Trademarks can be some of the most valuable assets held by a company, when it has created a name for itself in an industry. Some companies even license out their trademarks to other companies in exchange for royalties on the products that are sold. This allows the company to receive income from a market that is not their main focus, without all the costs involved in producing the products. Some companies that start out would do this to exponentially increase their customer base when their products enter the market. Then, when they have made a good name for themselves, they would only use their own branding. This has become a very profitable part of many businesses (Cetindamar *et al.*, 2010).

The main function of a trademark is for a company to protect its distinctive sign. Trademarks protect a company from its competitors placing a similar mark on their products, which would cause confusion among customers. Customers would not be able to distinguish between the products produced by the different companies (Cetindamar *et al.*, 2010).

## A.5 Industrial Design

Industrial design protects the distinguishing design of a product. It protects the ornamental or aesthetic aspect of an article. One of the main areas where this is applied is in the fashion industry. Industrial design is an aspect of property law that is probably subject to the most differences between countries. In some countries, industrial designs function as copyrights, where registration is not necessary - only proof of the origin of the design has to be presented. In other countries it is registered under patents, as a design patent. Most countries to having it be a separate IPR, with its own registration method and term that it is valid for. They are usually valid for 10 years, but can be valid for 3 to 20 years (Cetindamar *et al.*, 2010; WIPO Staff, 2012).

The protection of industrial design works similarly to that of trademarks. It is to prevent competition from producing products that looks similar to those of the owner of the industrial design right. It exists to limit confusion in the market place (Cetindamar *et al.*, 2010).

## A.6 Trade Secrets

Trade secrets are details about a product, production or business strategy that are not disclosed to the public. This is the intellectual property of a company that is protected by means other than formal IPRs. Secrecy is the main form of protecting trade secrets. There are numerous strategies for dealing with trade secrets, but currently it is only necessary to know what a trade secret is and where its limitations lie (Cetindamar *et al.*, 2010).

A trade secret is only protected as long as it remains a secret. Many companies that aim to protect trade secrets have policies in place that restrict any photography on the premises, for example. Being in possession of trade secrets of another company is not illegal, but the method of obtaining the information can be illegal. For example, re-engineering a product and discovering trade secrets is legal, therefore, companies must reduce the number of trade secrets that competitors can find in their products. Corporate espionage, on the other hand, is illegal and if information is obtained in this way - if it is proven - can result in serious repercussions (Cetindamar *et al.*, 2010).

# Appendix B

# Commercial Incentives to Innovate

If innovation is assumed to be process innovation, innovation can be further divided into subcategories, namely: a drastic process innovation or a non-drastic process innovation. A drastic process innovation is an improvement on the current process to such an extent that the innovator can behave as the monopolist without being constrained by competition within the industry. Non-drastic innovation is an innovation that allows the innovator to gain a competitive advantage over its own competitors, but the rivals are still legally allowed to compete within the market (Arrow, 1962).

Figure B.1 shows what the impact of a drastic and non-drastic innovation has on a company. This figure represents a market for a homogeneous product, with profit located on the y-axis ($p$), and the quantity of products produced is located on the x-axis ($Q$) (Belleflamme and Peitz, 2010; Arrow, 1962).

At $p_m$ all companies are currently in perfect competition, which signifies that the cost of manufacturing is the same for all companies producing the same product, and all companies involved are selling their products at cost price, with no profit. The products are produced at a constant marginal cost ($C_0$). The demand in the market is based on the cost of the product. The higher the cost, the less the demand for the product - as can be seen in the demand curve ($D$). The Marginal Revenue Curve ($MR$) is the additional revenue that will be generated by an increase in product sales (Belleflamme and Peitz, 2010; Arrow, 1962).

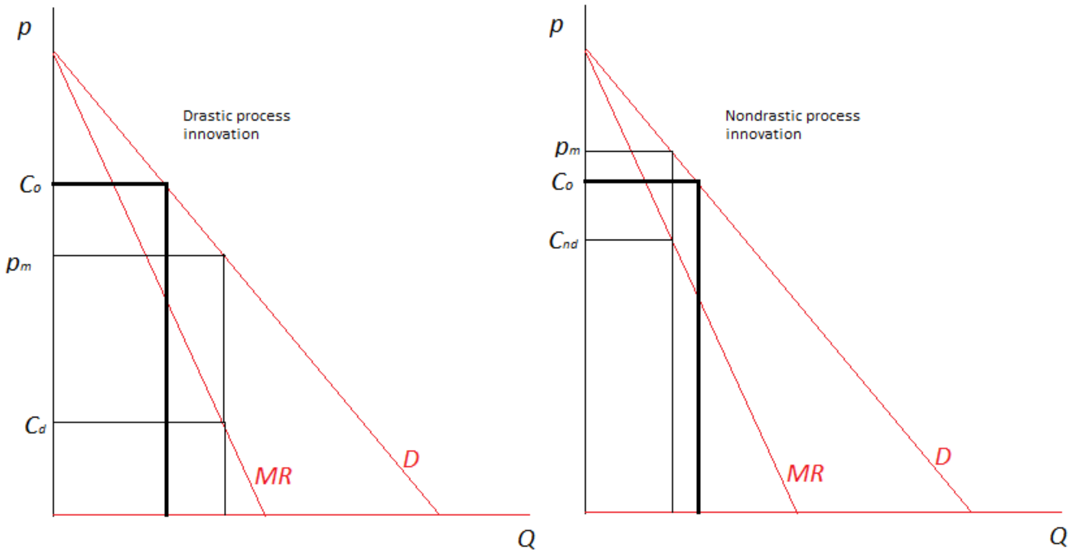


**Figure B.1:** Drastic vs Non-drastic Process innovations (*adapted from Belleflamme and Peitz (2010) and Arrow (1962)*

When a drastic process innovation takes place, the marginal cost of producing the product ($C_d$) is reduced to such an extent that the monopoly price for the product ($p_m$) falls below the constant marginal cost point ($c_0$). This means the company with the drastic innovation will become the monopolist, because it can saturate the market, and do so at a lower cost than its competitors. This will essentially cause its competitors to either stop producing the product, or produce it at a loss (Belleflamme and Peitz, 2010; Arrow, 1962).

In a case where a non-drastic process innovation is acquired by a company, the marginal cost of producing a product ($C_nd$) is reduced, but not to such an extent that the company can fix the monopoly price. The company will still face competition, since they do not control enough of the market to fix their price. They will still produce the products at a reduced cost, so as to increase profits (Belleflamme and Peitz, 2010; Arrow, 1962).

Figure B.1 is a simple model displaying incentives to innovate. However, this is in a controlled environment where there is perfect competition and the cost of the innovation is not taken into account. The most crucial element that this model is missing is that it cannot determine how much a company is willing to invest in an innovation.

Arrow (1962) created the first model that draws a comparison between companies that would be more willing to invest in different market structures. The Arrow Model assumes that a non-drastic process innovation has been placed in the market, that the companies all have the same opportunity to buy the innovation, and that they are informed as to what exactly the innovation does and the impact it will have on their process. This simulates an exclusive licensing that is auctioned off to the highest bidder. This model also assumes that there are no financial constraints. Companies will spend the money on the innovation until their return on investment reaches zero, at which point they will stop bidding. The model also assumes that there is no threat of entry for a new firm into the market.

Arrow (1962) used the model shown in Figure B.1 to propose his theories. With his models, he tried to predict who would be willing to pay more for a non-drastic innovation in two types of market structures. The first market structure was a perfectly competitive market, and the second was in the market as a monopolist. His conclusions were that firms in a perfect competition market structure have the most incentive to innovate. A monopolist has less incentive to invest in a non-drastic innovation than in a company in a perfectly competitive market structure, because of the replacement effect.

The model is based on the assumption that the monopolist is already earning a positive profit, in which a competitive company just recuperates its costs. When a competitive company purchases a non-drastic innovation, all the additional profits generated by the innovation are additional income. In the case of the monopolist, it is already making a profit before the innovation is implemented. Only part of the addition income that is generated by an innovation.

The replacement effect is the reason why some companies, that are the monopolist in their current market structure, would attempt to become active or relevant in other market trends. Microsoft is an example of this with their launch of the X-box. They have the largest lead as the monopolist in the market of operating systems, and other software, that R&D in the other direction will produce a higher return on investment - especially in more competitive markets (Tirole, 1988).

The second model that will be discussed is the Gilbert/Newbery's Auction model, which attempts to model whether a monopolist, under threat of a new entry or a competitive company, will pay more for an innovation. The innovation being a non-drastic innovation.

In the monopolist case, there are two possible outcomes for the model. First, the incumbent purchases the innovation, and remains the monopolist. In the second, the challenger purchases the innovation and enters the market. Upon entering the market, the monopolist will lose its position and have to share it with the new entry, forming a duopoly. In the competitive market, the highest bidder becomes the new monopolist.

With the occurrence of a drastic process innovation, the holder of the new innovation will be the new monopolist. Both, the incumbent and the challenger will bid exactly the same for the innovation. The incentive to innovate for the incumbent is the difference between being the monopolist, and having a duopoly. In this case, it is opposite to the Arrow model, in that, the monopolist has a higher incentive to innovate than a competitive company. This is due to the the "efficiency effect": the fear of losing the monopoly position (Belleflamme and Peitz, 2010).

In the Gilbert/Newbery's model, the assumption is made that the company with the highest bid will certainly receive the patent, but this is not the case in reality. During the R&D phase of innovation, a company has no guarantee that the research will result in a technology that can be used, no matter how much money is invested.

The patent race model simulates a research project that is started in different companies attempting to produce the same technology. This model introduces time and uncertainty to the Gilbert/Newbery model. The patent race model portrays replacement effects return, and the challenger has a higher incentive to innovate than the monopolist. This leads to creative destruction, which was suggested in Schumpeter's main hypothesis (Czarnitzki and Kraft, 2004).

# Appendix C

# Case Studies

## C.1 Overview of Stellenbosch University

### C.1.1 South Africa Background

Over the past century, even though it has faced challenges, South Africa has been one of the most thriving economies in Africa. South Africa is a country with a rich endowment of natural resources, including gold, diamonds and platinum. This has given South Africa a unique advantage in growing its economy. However, the need for South Africa to diversify and continually develop other industries and capabilities has been highlighted by academia and underlined by government. The ability to continually produce higher complexity goods also supports continued income growth.

Knowledge has become the most valuable asset in today's economy. The countries with the largest economies are all knowledge-based countries. A knowledge-based economy is an economy in which knowledge is the basic form of currency, and where innovation drives economic growth (Alessandrini *et al.*, 2013). South Africa has identified this and is working towards having a more knowledge-based economy. A ten year plan for innovations has been established, starting in 2008 and ending in 2018. This is considered in more detain in Section C.1.1.2.

#### C.1.1.1 Universities' Openness to Collaboration

South African universities are very open to collaboration with industries, especially the higher ranked universities, which includes: Stellenbosch University, the University of Cape Town, and the University of Witwatersrand. The University of Stellenbosch and the University of Cape Town have been building their TTOs since 1999, encouraging collaboration with industries. All this time, they have been building a relationship with industry, and the TTOs have grown substantially (Alessandrini *et al.*, 2013).

The study conducted by Alessandrini *et al.* (2013) included an interview with people responsible for technology transfer at thirteen universities in South Africa. They were all asked about their opinions on collaboration between higher education institutions. Five of the thirteen representatives responded that they were not open to collaborations with other universities, and three were still undecided.

#### C.1.1.2 Innovation in South Africa

All over the world, government subsidies to higher education institutions are being reduced. Universities are, therefore, searching for alternative sources of income. Since the goal of universities is to generate knowledge, selling intellectual property (IP) is in line with the ultimate goal of a university.

Through careful management (Mainly through TTOs), universities, can leverage their production of IP to generate income. Some universities might not have a dedicated office, but they still employ people to manage it. Some universities also do not have the initial start-up capital to start these initiatives, resulting in under-resourced technology transfer activities (Alessandrini *et al.*, 2013).

South Africa has set five key principles to guide the ten-year innovation plan (Depatment of Science and Technology, 2007). These principles will indicate the goals that the country aims to reach.

1. Strategic capacity: It is important for the government to make strategic choices regarding what to invest in. South Africa has failed to convert ideas into economic growth in the past, therefore, making strategic choices about how to invest will help steer the economy.

2. Competitive advantage: The government should invest in areas that have the highest social return.

3. Critical mass: Key research areas must be encouraged. This is referred to as the "Grand Challenges".

4. Sustainable capacity: The R&D scale-up must be consistent throughout the whole system, to have the absorptive capacity - with each element relying on the other for the system to work.

5. Life-cycle planning: The R&D infrastructure must be set up for the long term, to continuously improve the innovation. This includes support for depreciation, development of skills and information on the running cost.

In this list, the Grand Challenges were mentioned. These Grand Challenges are identified by the Depatment of Science and Technology (2007) as the most important areas. Special attention is given to increase innovation in these areas. These Grand Challenges are:

1. The farmer to pharma value chain. This is to strengthen the bio-economy and be able to provide better and cheaper medication to the population of South Africa.

2. Space science and technology. Research in space science and technology will increase the knowledge generation capacity.

3. Energy security: The world is focused on energy consumption and moving towards cleaner energy generation. As South Africa's main source of power is coal, research in energy is important.

4. Global-change science with a focus on climate change. Again, the coal power generation is a process that emits high levels of green house gases. South Africa has to do its part in this research.

5. Human and social dynamics: This is to increase the standard of living of the people living in the country.

### C.1.2 South Africa as a Knowledge-Economy

South Africa's law on what qualifies as a patentable invention is as follows (Reichelt, 2007): A patent or preliminary patent can be granted for a new, non-obvious invention that can be applied in trade, industry, or agriculture. An invention may be a new product, process, application or composition, or an improvement to any existing product, process, application or composition. A patent provides ownership rights for a period of 20 years from the date of submission, and a preliminary patent provides these rights for 12 months. As in most countries, the patent application and details about the invention are released to the public 18 months after the patent has been filed, regardless of whether the patent has been granted, refused or is still being examined.

Higher education institutions focus on the development of entrepreneurial activities, to encourage economic development, and increased attention to social responsibility (Alessandrini *et al.*, 2013). According to Schwab (2015), higher education institutions play a vital role in increasing global competitiveness by increasing human capacity and efficiency. There are, however, many challenges that hinder the R&D and innovation capacity of a country. These challenges include poor student enrolment at universities (14% stated by Alessandrini *et al.* (2013)), lack of availability of engineers, scientists and researchers, high cost of innovation and insufficient collaborative partnerships for innovation and technology commercialization (Schwab, 2015).

To increase innovation in the country, venture capital funds are needed to help new, innovative firms start out. The most prominent of these funds available in South Africa is the University Technology Fund. The universities that are partners in the fund are: Stellenbosch University, the University of the Witwatersrand, the University of Cape Town, the University of the Western Cape, the Nelson Mandela Metropolitan University, the University of Johannesburg and the Cape Peninsula University of Technology (Innovus, 2016).

### C.1.3 Technology Transfer Offices

Reichelt (2007) states that South Africa identified key weaknesses that prevent research and development that needs to be addressed if innovation is to proceed unhindered. The weaknesses include: inadequate funding of national systems of innovation, declining research and development in the private sector, and challenges faced by intellectual property in new and emerging technologies.

According to international standards, South Africa has a very robust intellectual property system, and it has conformed to the requirements placed on countries by international communities. South Africa is part of the Paris Convention, the Patent Co-operation Treaty and the World Trade Organisation's Agreement on Trade Related Aspects of Intellectual Property (TRIP's) (Reichelt, 2007).

Even though South African universities are fairly open, TTO is fairly limited. In 2004, it was reported that only three institutions had full-time staff working at TTOs, with the two oldest TTOs being founded in 1999. These TTOs are considered young, since the Bayh-Dole act - as was discussed in Section **??** - was founded in 1980, and some TTOs have been running before 1977. The Bayh-Dole act was specific to the United States, but most countries followed suit and allowed the universities to keep the intellectual property they generate from public funds.

South African TTOs are new; pooling resources will help growth at all participating institutions, but most institutions are not open to this (Alessandrini *et al.*, 2013). Reichelt (2007) states that universities feel this contradicts their traditional roles of generating new, widely available knowledge. South Africa is, however, adjusting its policies to become more research orientated and to allow greater flexibility for publicly-funded research institutions to collaborate with the private sector. This is done to stimulate innovation and boost the economy (Reichelt, 2007).

South African TTOs are having trouble identifying IP that has the potential for commercialisation, due to the lack of sufficient capacity (Garduño, 2004). Trust between the inventor and the technology transfer professionals is the key in a successful technology transfer process (Sibanda, 2009). This trust takes time and effort to build, since it is based on the ability of the TTO to engage the inventor and emphasise the challenges that the inventor faces. This in addition to pro-actively assisting the inventor with extracting maximum value from their research.

There is an urgent need in to employ technically skilled personnel in South African TTOs. They can: promote the benefits of technology transfer to both the institution and the inventor, effectively identify potential commerciable inventions in the early stages, and monitor and persist in delivering a commercialised product. South Africa has increased its invention disclosures. Despite this, the IP that has the potential to become patentable and commercialise products remains small in comparison with the case in developed countries (Alessandrini *et al.*, 2013). Alessandrini *et al.* (2013) states that this is because of a combination of under-resourced TTOs and low levels of awareness. Most research done at these universities might also not be done with commercialisation in mind.

The government has committed to enhancing the innovation potential from higher education institutions, as can be seen in the Intellectual Property Rights from Publicly Financed Research and Development (IPR-PFRD) Act, released in 2010, and the founding of the National Intellectual Property Management Office (Alessandrini *et al.*, 2013).

South African higher educational institutions can form their own policies regarding IPR developed, since there is no national framework for publicly-funded research institutions with regard to intellectual property. This is a major advantage, since universities can tailor their policies to fit their needs. Higher education institutions who do not focus on the licensing of IPR would prefer a national framework, because in that case they would not have to spend time developing their own (Reichelt, 2007).

### C.1.4 University of Stellenbosch

The University of Stellenbosch is a public institution classified as a large university with over 28 000 enrolled students. The University consists of 64% undergraduate students and 36% post-graduate students of which about 2500 are international student (Quacquaelli Symonds, 2016).

#### C.1.4.1 Local, Regional and International Ranking

University rankings are always an important indicator when comparing universities to international standards. Two rankings are considered at to determine where Stellenbosch University is ranked. The first is the Times Higher Education (2016) World University Rankings and the second is Quacquaelli Symonds (2016) QS World University Rankings.

Times Higher Education (2016) uses Teaching, International Outlook, Industry Income, Research and Citations as its indicators to determine the ranking of universities. Some of the key statistics that are used are: No. of Full-Time Equivalent(FTE) Students, Student:Staff Ratio, International Students and Female:Male Ratio. The major disadvantage is that universities that are ranked lower than $200^{th}$ are ranked within a range, so it is not possible to know the exact ranking of a university in the range. Stellenbosch is ranked $301 - 350^{th}$ in the world and third in South Africa, while the University of Cape Town is ranked $120^{th}$ and University of the Witwatersrand at $201-250^{th}$.

There are, however, a few things to take note of. The first is that Stellenbosch University is ranked highest in Industry Income in South Africa, and received the same score as the universities that scored the highest with Industry Income. Industry Income is the measure of the university's ability to help industry with innovation, inventions and consultancy. It suggests the extent to which businesses are willing to pay for research as well as the university's ability to attract funding from commercial markets. It should also be noted that, although, Stellenbosch University stayed in the same ranking range ($301-350^{th}$), it has increased its score in Industry Income from 2014 to 2016.

Quacquaelli Symonds (2016) is the second world university ranking, which places Stellenbosch University at $395^{th}$. This ranking system uses: Academic Reputation, Employer Reputation, Student-to-Faculty Ratio, Citations per Faculty, International Faculty and Student Ratio. Stellenbosch University has been ranked similarly for the past five years. It is also ranked third in South Africa, with the University of Cape Town, and University of the Witwatersrand ranked higher. It is ranked $35^{th}$ in the BRICS countries.

#### C.1.4.2 Background of InnovUS

InnovUS, the technology transfer office at Stellenbosch University, is one of the largest and most well developed technology transfer offices in South Africa. Founded in 1999, it is one of the oldest technology transfer offices in South Africa (Quacquaelli Symonds, 2016; Alessandrini *et al.*, 2013; Innovus, 2016).

Stellenbosch University has filed an accumulation of 84 PCT (Patent Co-operation Treaty) patents between 2009 and 2015. InnovUS has also founded a wholly owned private company that assists InnovUS in the commercialisation activities, by creating start-up companies. This company is called Unistel Group Holding Ltd.

#### C.1.4.3 Innovation Centres

The University of Stellenbosch has, at present, two incubator facilities. The Launch Lab is the most prominent one. It houses multiple spin-off companies from research done at Stellenbosch University. The second is the ERC (Early Research Career) programme (Alessandrini *et al.*, 2013).

#### C.1.4.4 Funds Available for Innovation

In South Africa there are programs that encourage university-industry linkages, these include the Technology and Human Resource for Industry Programme (THRIPs) and the Technology Innovation Agency (TIA). The TIA is a funding agency, that assists eligible South African institutions and researchers with their technology transfer activities. It is structured to house the Intellectual Property Management Office (IPMO) and the Innovation Fund Commercialisation Office (IFCO), which specifically provides support for intellectual property management and technology commercialisation. Both the IPMO and the IFCO provides technical assistance and capacity building for exploiting IP.

The THRIPs is another source of funding that is available for to assist research at South African universities aid in the process of commercialisation. It is managed by the Department of Trade and Industry, and uses this fund to encourage university-industry partnerships. The THRIPs shares the cost of R&D with industries and remove the risk of developing commercial technology from research institutions (Innovus, 2016).

In terms of capital available to stimulate research, Stellenbosch University sets aside an annual budget of R1.2 billion in the budget dedicated to research. This is for research that is done in the normal operations of the university, and can be classified as basic research. The majority of the research done with these funds will not be commercialised. The TRIPs funding provides R18.57 million, as well as an additional R27.21 million from industry (Innovus, 2016). The TRIPs funding and money from industry are used exclusively to assist with industry-university collaboration.

South Africa also has a fund that is used to invest in new technologies that originate from Universities - the University Technology Fund. This fund has R400m to invest. The fund invests in technologies and businesses that can provide an expected 20% to 30% return on investment (Innovus, 2016).

#### C.1.4.5 University Intellectual Property Policies

Research that is protected and exploited by universities originate from two sources. The first is from the university itself, through researchers identifying a gap in the industry. The second originates from industry, as they outsource research to universities.

The research that originates from the university is licensed out through exclusive or non-exclusive licences to industry. The university retains ownership of all the IPR that it generates. This allows the university to further develop the technology, while it is used by the licensee.

The university must work closely with NIMPO (National Intellectual Property Management Office) when licensing out IPR. The South African government requires that every transaction of IPR by a university must be approved by NIMPO. All the licences must benefit South Africa and its people. Stellenbosch University also gives preference to the parties that made a material contribution to the R&D project, and BBBEE entities.

Non-exclusive licences are the preferred method of licensing out technologies. Exclusive licences can be taken out, but they have a few additional conditions. The technologies licensed out through exclusive licences must be manufactured, processed and otherwise commercialised within South Africa (Stellenbosch University, 2009).

Researchers who want to commercialise the research that resulted in IPR themselves can do this through spin-off companies. The university provides the researcher with the resources to start a new company by assisting with financial and administration. Stellenbosch University also allows the spin-off companies to lease out laboratory equipment for the duration of their stay as a spin-off company. The spin-off companies have to become self sufficient within two years. At that time, the company would have to move of the university premises and have its own infrastructures in place.

When it comes to research that is outsourced from industries to the university, the research can take two forms. The first is consultation. With consultations, the research will only provide the knowledge to solve a problem. No IPR will be generated from the consultation. Stellenbosch University does not claim any of the income from consultations, and all the income is assigned to the consultant. The university does, however, expect to be compensated if the consultant worked on the project during normal working hours, or used laboratory equipment.

Contract research refers to research that is outsourced by a company that will result in IPR. Ownership of the IPR will go to the university, but the company can purchase it from Stellenbosch University at full cost.

Full cost includes all the direct and indirect cost associated with generating the IPR. The direct costs include all the costs that were directly involved in the generation of the IPR. The indirect costs are all the behind the scenes costs, such as administration fees.

The company can also take out a license on the technology that was developed. Although the company will not have ownership of the technology, the cost of the license will be adjusted according to the funds that were invested by the company in the research.

When a technology is licensed out, the funds are divided amongst the university, the researcher/inventor and the innovation fund. Figure C.1 shows how these funds are divided at Stellenbosch University. InnovUS divides the licences into two groups: low income projects (less than R1m) and high income projects (More than R1m).

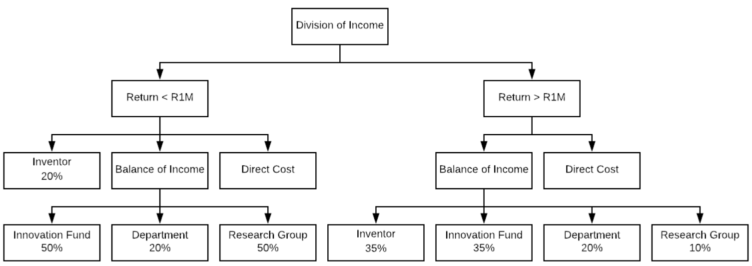


**Figure C.1:** Division of income from licenses sold from Stellenbosch University

## C.1.5 Government Subsidies

Government subsidies to encourage research outputs are assigned to universities through the Research Outputs Policy. The research can be published in three areas: journals, books and conference proceeding. Universities can only claim once for each output (Department: Higher Education and Training, 2015).

The journals must be accredited international or South African journals, and only original research that is done is accepted. The article will only add to the university's score once the article has been published, and not when the article is accepted for publication. The university receives 1 unit for each publication in such an accredited journal. No distinction is made regarding the prestige of the journal, as long as the journal is accredited by the DHET. Also, no distinction is made between national and international journals (Department: Higher Education and Training, 2015).

The books that are published must be for experts in the field. The purpose of the book must be to disseminate original research and new developments within a specific discipline or field of study. The book must be a minimum of 60 pages long, and 1 unit is assigned for every 60 pages. The university can receive a maximum of 10 units from a book (Department: Higher Education and Training, 2015).

The final research output is that of conference proceedings. The conference proceedings have to be approved, and it must be original research that is presented to experts in the field. The university can either apply for 0.2 unit for a local proceeding and 0.3 units for an international proceeding (Department: Higher Education and Training, 2015).

The universities receive funding based on the number of units generated during the course of the year. The funding is assigned to the university, and the university assigns the funding to three subcommittees. These subcommittees comprise of all departments. The subcommittees are:

1. Subcommittee A: Art and Social Sciences, Education, Law, Theology, Economic, Management Sciences and Military Sciences
2. Subcommittee B: Science, Agricultural Science and Engineering
3. Subcommittee C: Medicine and Health and Science

The subcommittees divide the income between the departments based on the units that were generated by the different departments. Each department will have its own policy in place for dividing the funds between the research groups and researchers.

## C.2 Overview of the Katholieke Universiteit Leuven

KU Leuven is considered an extra large university, according to Quacquaelli Symonds (2016), with more than 50 000 students currently enrolled. The university consists of 53% postgraduate students and 47% undergraduate students (Quacquaelli Symonds, 2016).

The KU Leuven Technology Transfer Office is called the KU Leuven Research and Development (LRD) department. This is one of the oldest and most successful technology transfer offices in Europe, having operated since 1972 (Edmonson, 2015).

As with all aspects of research and development, the department has taken a long time to get on its feet, as it takes a long time to realise any return on investment. Currently, the most successful licences in terms of revenues, are based on inventions made in the 1990's. There are payments made to the university as milestone payments and licensing fees, but the university only receives the royalty payments - which are the highest form of revenue generation, if the product is on the market (Edmonson, 2015).

This technology transfer office has become a model for other European universities, as it is able to overcome the European Paradox. KU Leuven is ranked sixteenth in the world in terms of innovative universities. It is the most innovative university in main land Europe, and second in Europe including the United Kingdom (Ewalt, 2015).

The "European Paradox" is the gap between the high level of scientific performance by universities, and their lack of involvement in the industry. Bill Gates referred to this by saying that it is not the lack of knowledge in Europe that is the problem, but more the lack of knowledge based companies. The LRD has overcome this limitation, and is able to do effective business with the industry (Edmonson, 2015).

### C.2.1 Belgium Background

The Flemish government places very few restrictions on research collaboration between universities and industries. One of the main restrictions are that all the costs for the research should be covered by the principal of the contract. These expenses include the use of the infrastructure and services of the personnel from the university. The other major restriction is that all research collaboration contracts have to be approved by university administration.

The lack of restrictions gives the university the freedom to install their own internal regulations for collaborating with companies, that suit their strategy. In these regulations they can stipulate the minimum overhead cost that must be applied in these contracts, the method of payment and the possibility of personal remuneration for researchers (Debackere and Veugelers, 2005).

As for investing in spin-off companies, the university is only allowed to invest in companies that originate from research done at the university. The university is allowed to accept shares in the company in exchange for intangible assets, but they are never allowed to own the majority voting rights (Debackere and Veugelers, 2005).

#### C.2.1.1 Universities Openness to Collaboration

Universities in Belgium are open to collaboration with both industries and other higher education institutions. This is evident in the fact that KU Leaven has one of the most successful Technology Transfer Offices in the world. KU Leuven also formed a group of colleges and universities in Belgium called the KU Leuven Association.

### C.2.2 Belgium as an Knowledge-Based Economy

Belgium's R&D as a percentage of their GDP is generally close to the European average, so in terms of innovation it is not ranked very high. Its production of knowledge is not as high as other countries that are known for this, like the USA, Finland, England and Japan. Belgium has a less pronounced high-tech industry, focusing more on the higher segments of medium-tech industries, such as engineering and machinery, chemicals, vehicles, electrical machinery and commodity materials. These industries focus more on the rapid adaptation of new process technologies, rather than generating new technology breakthroughs. Even though Belgian firms do not focus on innovation in their own companies, they are very practised in implementing new knowledge, produced at research institutions, in their production lines (Debackere and Veugelers, 2005).

Most of the companies that exist in Belgium are small to medium sized. Of these companies, it is the small companies that focus on generating knowledge, and being innovative (Debackere and Veugelers, 2005). Since these companies are small, they struggle to compete on an international level, where large industries have more research groups and capital - to spread the risks of R&D

over multiple projects (Czarnitzki and Kraft, 2010).

Universities in Belgium are doing very well in supplying knowledge by producing high quality papers in scientific journals all across the world. The Belgian government invests a relatively large amount of funds in R&D at higher education institutions, of which KU Leuven receives the largest amount (Debackere and Veugelers, 2005).

The universities notwithstanding, Belgium also has numerous public and semi-public research institutions - varying in both size and objectives. The most notable of these is IMEC, which is the largest research institution that specialises in nano-technologies in the world. It is located just outside the KU Leuven campus in Leuven (Czarnitzki and Kraft, 2010; van den Broeck, 2006).

### C.2.3 Technology Transfer Offices

There are some key points that Prof. Rik Trofs, the current rector at KU Leuven, points out as instrumental to the success of the LRD in an interview conducted by Edmonson (2015). The most important is the fact that the leadership of the university understands how it works, and has a vision for the development of the department. The department is completely autonomous, managing its own finances and legal processes, but it is still contained within the university. This freedom allows the department to choose where to invest the money, and not have to lose some of it to other departments in the university.

The LRD does not use government subsides to replace their own money that they spend on R&D, but rather use it to increase their current pool of investment capital. The LRD invests 83% of their income back into innovation and the creation of knowledge, and only 17% of the profits are given to the university. This allows the University to continually increase the innovation that it is generating (Edmonson, 2015).

When dealing with governments or public companies, the legislation on public contracts has to be taken into account. The Belgian legislation takes priority over European legislation. This legislation allows the LRD to place these research groups in a competitive situation, which results in the best quality/cost ratio (LRD, 2016).

### C.2.4 KU Leuven

Research is rarely done for the sake of research. Even in exploratory research, there is always a goal or an objective that the research aims to reach. Also, if research will not provide answers that can be commercialised, there is a very small chance that funding for the research will continue. Since most research is done to be used in the future, protecting the research is important to any research institution.

KU Leuven has the legal status of a private university, but receives 85% of its funding from the Belgian government. It employs 1400 professors and 3500 researchers, and teaches 50 000 students a year. It recorded 3126 publications in international peer-reviewed ISI-recorded scientific journals in 2003 (Debackere and Veugelers, 2005).

#### C.2.4.1 Local, Regional and International Ranking

Three rankings are looked at with respect to KU Leuven. Times Higher Education (2016) World University Ranking and Quacquaelli Symonds (2016) QS World University Rankings are considered, and the third is the Reuters Innovative University rankings Ewalt (2015, 2017).

Quacquaelli Symonds (2016) ranks KU Leuven $79^{th}$ in the world. KU Leuven is ranked first in Belgium and $25^{th}$ in Europe. The university is ranked $35^{th}$ according to Times Higher Education (2016) World University Ranking.

The Reuters ranking system, ranks universities according to innovation, and only lists the top 100. KU Leuven's ranking has improved quite substantially over the last few years. KU Leuven was ranked $16^{th}$ in the world and second in Europe in 2015 and was also ranked first in main land Europe. The latest Reuters ranking that was released in 2017, ranks KU Leuven as the $5^{th}$ most innovative university in the world, and the highest ranking university outside the United States Ewalt (2015, 2017).

#### C.2.4.2 Innovation Support Systems and Identification

In addition to technology transfer services, the LRD helps professors, researchers and scientists with many tasks that do not directly produce income for the university, but help with the academic advances in their research. They are involved with the ordering of equipment and materials that are needed for experiments and doing the conducting research. They do this without any additional costs to the professors. This is just one of the systems they have in place to encourage professors and researchers to talk to them about their research. If the LRD is informed about the research that is taking place, they can organise collaboration - not only between industries, but also between departments. Since universities are quite vast in general, most professors do not know what research is conducted outside of their own department. The LRD has these systems in place to detect when similar research projects are being conducted, so that resources and expertise may be shared (Edmonson, 2015).

KU Leuven LRD sets up collaborative projects with companies and organisations, assisting with the drafting, negotiating and monitoring of these agreements. It provides legal assistance for everyone that forms part of the KU Leaven Association. It also provides guidance for the distribution of funds, given by the Flemish and European government, between different research projects in the KU Leuven Association (LRD, 2016).

Another function of the LRD is the coordination between the different institutions in the KU Leuven Association. When a research project requires help from a different research group, whether in their own institution or in the KU Leuven Association, the LDR arranges an agreement with that required research group. They also coordinate things like consultancy, laboratory tests and framework agreements (LRD, 2016).

There are two more services that the LRD provides. The first is subcontracting agreements, which are set up for a research team working on a small part of a large project. The second is public contracts provided by the government to the university.

The LDR also assists with financial monitoring of research and development taking place in the KU Leuven Association. They do the financial management of research files, patents, licences and spin-off transactions. This is to reduce the financial management load of divisions in the association (LRD, 2016).

### C.2.4.3 Background of LRD

The LDR acts as a one-stop shop for the university, covering every aspect from the creation of an invention to the commercialisation of the invention. The LRD department at KU Leuven not only manages the intellectual property by securing and licensing intellectual property rights, but they also manage research collaborations with industries, encourage the creation of spin-off countries and stimulate regional development (LRD, 2016; Edmonson, 2015).

In 2003, it was reported by Debackere and Veugelers (2005) that the LDR was employing 26 full time staff focusing on the managing the financial and legal departments, as well as managing collaboration. Edmonson (2015) states that this number has risen to 85 people, of which half is support staff working on finance, structuring and administrating collaborations, while the other half purely works on technology transfer. Ten people work on IP and business development. These people are qualified in IP and have backgrounds in various fields of study. They identify potential deals that could be made, as they understand the technical background. Seven people manage the spin-off companies, and five lawyers are on the legal staff. These lawyers, although they have a full understanding of the law, focus on making deals with companies.

The LRD at KU Leuven is tasked with the protection of the research that is done in the KU Leuven Association. They handle all the paperwork and negotiations for work performed for third parties. Negotiating the research collaboration contract is one of major functions of this department. In this contract they will state the cost of the research, the department and researchers working on it, and the monitoring of the project. The monitoring of the project will provide the company, or organization a tool to determine how the project is progressing (LRD, 2016).

The LRD fulfils multiple functions, which are each handled by different sections in the department. These sections are shown in Figure C.2

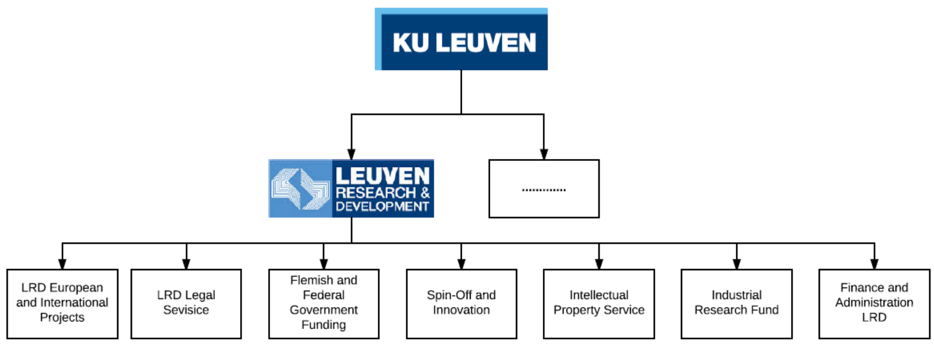


**Figure C.2:** LRD Organisation Structure

With collaborative R&D projects being so vastly different, it is impossible to have a 'standard' research or service agreement. A new agreement will have to be made for every project, since every research has different expected outcomes. These projects are handled on a case by case basis. Legal advisers and researchers work together to see what needs to be done. They will then discuss which 'template' agreement works best for the project (LRD, 2016).

In the start-up phase of a project, a standard no-disclosure agreement will be signed, to give the companies security when the project is starting out.

These are mandatory in some cases. There are, however, several routine services that KU Leuven provides in which no new knowledge is generated. In these cases, the LRD holds standard agreements (LRD, 2016).

The LDR's Intellectual Property Rights manages the patent portfolio of the KU Leuven Association. They negotiate and sell licences to companies who needs access to these technologies. They are also in charge of acquiring the patents that are required to sell the complete technology to outside entities.

Patent portfolios become more valuable if more of a technology is contained in the portfolio. The fewer patents for a technology are contained in a patent portfolio, the more likely it is for a company to design around the patent portfolio held by the university. This would render the patents almost worthless, as universities would not be able to prevent others from using the technologies.

The more patents a patent portfolio contains of a certain technology, the more likely it is that a company would take out a licence on the technology, instead of designing around it. This acquisition of patents will be done by purchasing, or by R&D. However, this will only be done when there is a market for the technology (LRD, 2016).

#### C.2.4.4 Innovation Centres

A university is a part of society that focuses new, innovative research in different fields of study. It brings together highly skilled people in both the same and different fields, presenting an opportunity for them to start new businesses in their fields of study.

The KU Leuven and some industries have come together to create a support system for these new, innovative firms emerge from the universities. Most of the businesses that are started are spin-off companies, coming from researchers that want to commercialise their research. KU Leuven also helps evolve companies that are not necessarily spin-off companies, but are new, and innovative.

KU Leuven has three types of innovation hubs to help the growth of businesses. The first is a Science Park, in which the companies can hire part of the facility to do research in. This brings companies with similar interests together and allows them to solve similar problems together. The incubators are for spin-off companies. Here, these new companies are supplied with facilities to continue their research, as well as a support structure to help them in the early stages of managing their businesses. The final innovation hub is the business centre. The business centre acts as a basic support structure for new businesses that are not necessarily spin-off companies.

### C.2.5 Available Funds for Innovation

Protecting and managing Intellectual Property is an important step in the starting up and growing company. During this phase, the company is still new to the industry and so effectively creating "Freedom-To-Operate" is essential if the company wants to survive. This is done by the Intellectual Property Rights Service of the LDR, in close cooperation with experts in an extensive network of European patent attorneys. They also help with identifying the correct patenting strategy.

The LRD assists companies with legal issues during the start-up phase. They help the spin-off company deal with the development of the shareholder structure, as well as the drafting of the articles of association, as well as the shareholder, technology transfer and cooperation agreements for the use of infrastructure at KU Leuven.

Internal and sometimes external advisers help start-up companies transform business ideas into a business plans. Due to the highly innovative nature of these spin-off companies, each business model has to be tailor-made for the company. The technology expertise of the researchers who start the company is combined with the business expertise of the staff working at the LRD. This produces the required business plan for starting out. This combination of expertise allows the idea for the business to be clearly stated - acting as an introduction for potential investors, as well as a guideline for the entrepreneurs in the early stages of the business. The LRD works with the spin-off company to evaluate potential markets. They also help in securing early industrial contracts for the work they are doing.

The change from researcher to entrepreneur is not easy, and additional skills are needed to start a company. A company requires people who are skilled in management, sales, and finance to start up. If these skills are not available in the initial team, outside help will be required. The LRD has a team that assists these spin-off companies in acquiring people who can fulfil these roles (LRD, 2016).

KU Leuven has partnered with two major private banks - KBC Private Equity and BNP Paribas Fortis Private Equity - to create the Gemma Frisius Fund. The goal of the Gemma Frisius Fund is to provide seed capital for these innovative, research based spin-off companies in their early stages. The LRD also has an extensive network of local and international investors, who would assist in starting up these businesses, increasing the start up capital of these companies (LRD, 2016).

LRD helps spin-off companies find the initial infrastructure that is needed. These companies are placed in either the Innovation and Incubation Centre (I&IC), the bio-incubator or the science park in the Leuven high-tech region.

The LRD maintains close ties with these spin-off companies after their first years, ensuring that the companies keeps on developing their strategic visions. They also help the company through the various phases of growth, by giving advice about strategic decisions for international growth. This is done by keeping someone from the LRD on the board of the company.

Furthermore, the LRD provides courses in entrepreneurship for Ph.D. students. In these courses, the PhD students have to create a business plan for turning their current research into a spin-off company. With these courses, the researchers have started taking the first steps in starting spin-off companies. KU Leuven also provides courses in entrepreneurship that are open to everyone.

The LRD focuses on establishing and maintaining close relationships with the local, regional, national and European governments, as well as with local and international companies. The LRD has been involved in setting up networks and clusters to help with industry development. These networks include Leuven Inc., DSP Valley, and LSEC (Leuven Security Excellence Consortium).

### C.2.6 University Intellectual Property Policy

The IPR policies of KU Leuven are also divided into research originating from the university, and research outsourced from industry. KU Leuven also does not claim any income from consultations - the consultant will receive all the income.

The main difference between the contract research done at KU Leuven and Stellenbosch University is that KU Leuven only requires the direct cost of the research to be covered when the IPR is purchased, and not all the indirect costs.

Non-exclusive licences are also the preferred form of licensing, but KU Leuven does not have any limitations on exclusive licences, as is the case at Stellenbosch University.

The income from royalties is divided between four entities: the university, the TTO, the inventor/researcher and the innovation fund. In this case the income to the university goes to the administration of the university. The university and the TTO always receive a fixed percentage of the income, no matter how profitable the project is. As the profitability of the research increases, the inventor/researcher will receive a smaller portion of the income, and the innovation fund will receive a larger portion. The break down of the division of income is shown in Figure C.3

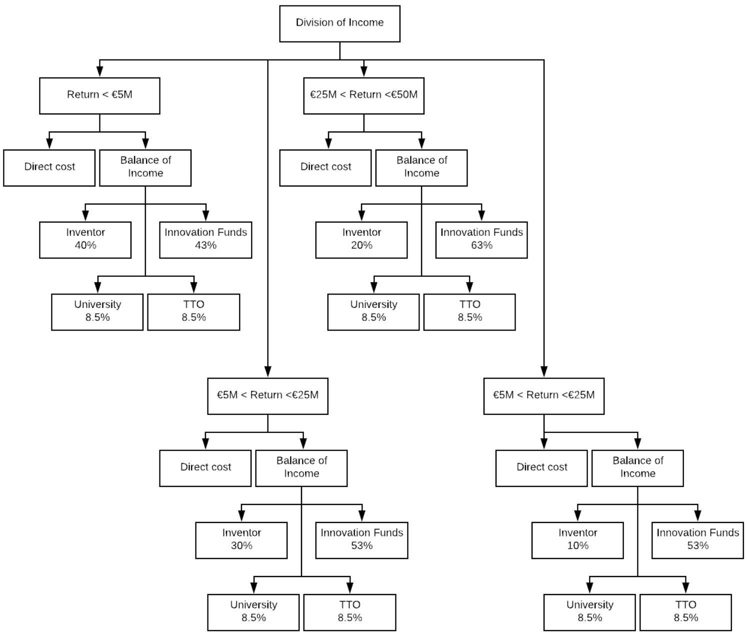


**Figure C.3:** Division of income from licenses sold from KU Leuven

## C.2.7 Government Subsidies

The Belgian government's subsidies to universities are assigned according to a index that relies on 4 variables, that each have equal weighting. The government subsidies are determined by using the following variables:

1. Number of PhD degrees are awarded
2. Number of Publications
3. Number of Citations (H-Index)
4. Percentage of International Students.

KU Leuven receives 43% of the funding that is available for subsidising universities in Belgium. Thus it receives the largest portion of income set aside for universities by the government.

# Appendix D

# Data

**Table D.1:** Data - Stellenbosch University

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 22,768 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 28% | (Quacquaelli Symonds, 2017) |
| Total Revenue | R4,702M | (Steyn, 2017) |
| Country | South Africa | (Schwab, 2015) |
| # of Staff | 794 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Gumbo (10.15) | (Web of Knowledge, 2017) |
| # of National Patents | 299 | (European Patent Office, 2016) |
| % PCT Patents | 41% | (European Patent Office, 2016) |
| % Success Patents | 51% | (European Patent Office, 2016) |
| University QS Ranking | 405 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R265,400.00 | (Steyn, 2017) |
| Number of Legal Staff | 4 | (InnovUS, 2017) |
| Quality of Country's Science and Education (Rank) | 114 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 36 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 23 | (InnovUS, 2017) |
| Division of Income: Innovation Fund | 25% | (InnovUS, 2010) |
| Country Venture Capital (Rank) | 66 | (Schwab, 2015) |
| Income from Industry | R436M | (Steyn, 2017) |
| Income from Government | R1,882M | (Steyn, 2017) |
| Income from Student Fees | R1,282M | (Steyn, 2017) |
| Income from Investments | R1,102M | (Steyn, 2017) |
| GDP per Capita (US$) | $5,260.90 | (Schwab, 2015) |
| Division of Income: University | 25% | (InnovUS, 2010) |
| Division of Income: Inventor | 50% | (InnovUS, 2010) |
| Number of Publications (2007 - 2017) | 20,551 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 1.25 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 2008 | (Nkomo, 2017) |
| Date of Release:University IP Policy | 2004 | (InnovUS, 2017) |
| Date of Revision: National IP Policy | 2017 | (Nkomo, 2017) |
| Date of Revision: University IP Policy | 2010 | (InnovUS, 2017) |
| Number of Non-Legal Staff at TTO | 16 | (InnovUS, 2017) |
| Number of Spin-Offs | 24 | (InnovUS, 2017) |

**Table D.2:** Data - KU Leuven

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 45,422 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 51% | (Quacquaelli Symonds, 2017) |
| Total Revenue | 933M Euro | (Torfs, 2016) |
| Country | Belgium | (Schwab, 2015) |
| # of Staff | 2569 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Staessen (42.59) | (Web of Knowledge, 2017) |
| # of National Patents | 623 | (European Patent Office, 2016) |
| % PCT Patents | 59% | (European Patent Office, 2016) |
| % Success Patents | 33% | (European Patent Office, 2016) |
| University QS Ranking | 81 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R17,400.00 | (Torfs, 2016) |
| Number of Legal Staff | 10 | (LRD, 2016) |
| Quality of Country's Science and Education (Rank) | 7 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 8 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 94 | (LRD, 2016) |
| Division of Income: Innovation Fund | 36% | (LRD, 2016) |
| Country Venture Capital (Rank) | 20 | (Schwab, 2015) |
| Income from Industry | 146M Euro | (Torfs, 2016) |
| Income from Government | 628M Euro | (Torfs, 2016) |
| Income from Student Fees | - Euro | (Torfs, 2016) |
| Income from Investments | 160M Euro | (Torfs, 2016) |
| GDP per Capita (US$) | $41,283.30 | (Schwab, 2015) |
| Division of Income: University | 14% | (LRD, 2016) |
| Division of Income: Inventor | 50% | (LRD, 2016) |
| Number of Publications (2007 - 2017) | 29,989 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 13.38 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 1991 | (Hanssens, 2016) |
| Date of Release:University IP Policy | 1972 | (LRD, 2016) |
| Date of Revision: National IP Policy | 2017 | (Hanssens, 2016) |
| Date of Revision: University IP Policy | 2017 | (LRD, 2016) |
| Number of Non-Legal Staff at TTO | 180 | (Web of Knowledge, 2017) |
| Number of Spin-Offs | 110 | (Web of Knowledge, 2017) |

**Table D.3:** Data - University of Witwatersrand

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 27,080 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 13% | (Quacquaelli Symonds, 2017) |
| Total Revenue | R4,855M | (Technology Transfer Office, 2012) |
| Country | South Africa | (Schwab, 2015) |
| # of Staff | 381 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Gumbo (10.15) | (Web of Knowledge, 2017) |
| # of National Patents | 299 | (European Patent Office, 2016) |
| % PCT Patents | 41% | (European Patent Office, 2016) |
| % Success Patents | 51% | (European Patent Office, 2016) |
| University QS Ranking | 405 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R265,400.00 | (Technology Transfer Office, 2012) |
| Number of Legal Staff | 4 | (Wits Enterprise, 2017) |
| Quality of Country's Science and Education (Rank) | 114 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 36 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 23 | (Wits Enterprise, 2017) |
| Division of Income: Innovation Fund | 25% | (Technology Transfer Office, 2012) |
| Country Venture Capital (Rank) | 66 | (Schwab, 2015) |
| Income from Industry | R436M | (Technology Transfer Office, 2012) |
| Income from Government | R1,882M | (Technology Transfer Office, 2012) |
| Income from Student Fees | R1,282M | (Technology Transfer Office, 2012) |
| Income from Investments | R1,102M | (Technology Transfer Office, 2012) |
| GDP per Capita (US$) | $5,260.90 | (Schwab, 2015) |
| Division of Income: University | 25% | (Technology Transfer Office, 2012) |
| Division of Income: Inventor | 50% | (Technology Transfer Office, 2012) |
| Number of Publications (2007 - 2017) | 20,551 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 1.25 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 2008 | (Nkomo, 2017) |
| Date of Release:University IP Policy | 2004 | (Wits Enterprise, 2017) |
| Date of Revision: National IP Policy | 2017 | (Nkomo, 2017) |
| Date of Revision: University IP Policy | 2010 | (Wits Enterprise, 2017) |
| Number of Non-Legal Staff at TTO | 16 | (Wits Enterprise, 2017) |
| Number of Spin-Offs | 24 | (Wits Enterprise, 2017) |

**Table D.4:** Data - University of the Free-State

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 20,689 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 14% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | South Africa | (Schwab, 2015) |
| # of Staff | 1175 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Swart (8) | (Web of Knowledge, 2017) |
| # of National Patents | No Data | N/A |
| % PCT Patents | No Data | N/A |
| % Success Patents | No Data | N/A |
| University QS Ranking | No Data | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R265,400.00 | (Technology Transfer Office, 2012) |
| Number of Legal Staff | No Data | N/A |
| Quality of Country's Science and Education (Rank) | 114 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 36 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | N/A |
| Division of Income: Innovation Fund | No Data | N/A |
| Country Venture Capital (Rank) | 66 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | N/A |
| Income from Student Fees | No Data | N/A |
| Income from Investments | No Data | N/A |
| GDP per Capita (US$) | $5,260.90 | (Schwab, 2015) |
| Division of Income: University | No Data | N/A |
| Division of Income: Inventor | 50% | (Technology Transfer Office, 2012) |
| Number of Publications (2007 - 2017) | 22,590 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 6.8 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 2008 | (Nkomo, 2017) |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | 2017 | (Nkomo, 2017) |
| Date of Revision: University IP Policy | 2012 | Research Contracts and Innovation (2012) |
| Number of Non-Legal Staff at TTO | No Data | N/A |
| Number of Spin-Offs | No Data | N/A |

**Table D.5:** Data - University of Johannesburg

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 18884 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 10% | (Quacquaelli Symonds, 2017) |
| Total Revenue | R4,104M | (Burger, 2017) |
| Country | South Africa | (Schwab, 2015) |
| # of Staff | 412 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Behera (3) | (Web of Knowledge, 2017) |
| # of National Patents | No Data | N/A |
| % PCT Patents | No Data | N/A |
| % Success Patents | No Data | N/A |
| University QS Ranking | 551-560 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R265,400.00 | (Technology Transfer Office, 2013) |
| Number of Legal Staff | No Data | N/A |
| Quality of Country's Science and Education (Rank) | 114 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 36 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | N/A |
| Division of Income: Innovation Fund | No Data | N/A |
| Country Venture Capital (Rank) | 66 | (Schwab, 2015) |
| Income from Industry | R485M | (Burger, 2017) |
| Income from Government | R1,721M | (Burger, 2017) |
| Income from Student Fees | R1,691M | (Burger, 2017) |
| Income from Investments | R207M | (Burger, 2017) |
| GDP per Capita (US$) | $5,260.90 | (Schwab, 2015) |
| Division of Income: University | No Data | N/A |
| Division of Income: Inventor | | N/A |
| Number of Publications (2007 - 2017) | 27863 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 2.67 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 2008 | (Nkomo, 2017) |
| Date of Release:University IP Policy | 2007 | (Technology Transfer Office, 2013) |
| Date of Revision: National IP Policy | 2017 | (Nkomo, 2017) |
| Date of Revision: University IP Policy | 2013 | (Technology Transfer Office, 2013) |
| Number of Non-Legal Staff at TTO | No Data | N/A |
| Number of Spin-Offs | No Data | N/A |

**Table D.6:** Data - University of Pretoria

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 43,803 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 19% | (Quacquaelli Symonds, 2017) |
| Total Revenue | R2,236M | Sauer (2017) |
| Country | South Africa | (Schwab, 2015) |
| # of Staff | 381 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Archer (5) | (Web of Knowledge, 2017) |
| # of National Patents | 34 | (European Patent Office, 2016) |
| % PCT Patents | 18% | (European Patent Office, 2016) |
| % Success Patents | 52% | (European Patent Office, 2016) |
| University QS Ranking | 561-570 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R265,400.00 | (Technology Transfer Office, 2012) |
| Number of Legal Staff | 6 | Sauer (2017) |
| Quality of Country's Science and Education (Rank) | 114 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 36 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | N/A |
| Division of Income: Innovation Fund | 25% | (Technology Transfer Office, 2010) |
| Country Venture Capital (Rank) | 66 | (Schwab, 2015) |
| Income from Industry | R61M | Sauer (2017) |
| Income from Government | R1,293M | Sauer (2017) |
| Income from Student Fees | R882M | Sauer (2017) |
| Income from Investments | R- | Sauer (2017) |
| GDP per Capita (US$) | $5,260.90 | (Schwab, 2015) |
| Division of Income: University | 25% | (Technology Transfer Office, 2010) |
| Division of Income: Inventor | 50% | (Technology Transfer Office, 2010) |
| Number of Publications (2007 - 2017) | 27,227 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 3.94 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 2008 | (Nkomo, 2017) |
| Date of Release:University IP Policy | 2004 | (Technology Transfer Office, 2010) |
| Date of Revision: National IP Policy | 2017 | (Nkomo, 2017) |
| Date of Revision: University IP Policy | 2010 | (Technology Transfer Office, 2010) |
| Number of Non-Legal Staff at TTO | 2 | (Wits Enterprise, 2017) |
| Number of Spin-Offs | No Data | N/A |

**Table D.7:** Data - University of Cape Town

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 20,758 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 28% | (Quacquaelli Symonds, 2017) |
| Total Revenue | R3,000M | Price (2017) |
| Country | South Africa | (Schwab, 2015) |
| # of Staff | 1691 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Zhu (31) | (Web of Knowledge, 2017) |
| # of National Patents | 97 | (European Patent Office, 2016) |
| % PCT Patents | 21% | (European Patent Office, 2016) |
| % Success Patents | 56% | (European Patent Office, 2016) |
| University QS Ranking | 200 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R265,400.00 | (Steyn, 2017) |
| Number of Legal Staff | 6 | (TTO, 2017) |
| Quality of Country's Science and Education (Rank) | 114 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 36 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 17 | (TTO, 2017) |
| Division of Income: Innovation Fund | 33% | (Technology Transfer Office, 2011) |
| Country Venture Capital (Rank) | 66 | (Schwab, 2015) |
| Income from Industry | R321M | (Price, 2017) |
| Income from Government | R1,370M | (Price, 2017) |
| Income from Student Fees | R1,307M | (Price, 2017) |
| Income from Investments | R- | (Price, 2017) |
| GDP per Capita (US$) | $5,260.90 | (Schwab, 2015) |
| Division of Income: University | 34% | (Technology Transfer Office, 2011) |
| Division of Income: Inventor | 33% | (Technology Transfer Office, 2011) |
| Number of Publications (2007 - 2017) | 33,953 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 4.63 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 2008 | (Nkomo, 2017) |
| Date of Release:University IP Policy | 2011 | (Technology Transfer Office, 2011) |
| Date of Revision: National IP Policy | 2017 | (Nkomo, 2017) |
| Date of Revision: University IP Policy | 2011 | (Technology Transfer Office, 2011) |
| Number of Non-Legal Staff at TTO | 14 | (TTO, 2017) |
| Number of Spin-Offs | 19 | (TTO, 2017) |

**Table D.8:** Data - University of Antwerp

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 15,096 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 42% | (Quacquaelli Symonds, 2017) |
| Total Revenue | 278M Euro | (van Goethem, 2016) |
| Country | Belgium | (Schwab, 2015) |
| # of Staff | 2569 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Berneman (40) | (Web of Knowledge, 2017) |
| # of National Patents | 6 | (European Patent Office, 2016) |
| % PCT Patents | 67% | (European Patent Office, 2016) |
| % Success Patents | 0% | (European Patent Office, 2016) |
| University QS Ranking | 223 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R17,400.00 | (Torfs, 2016) |
| Number of Legal Staff | 9 | Valorisation Office (2017) |
| Quality of Country's Science and Education (Rank) | 7 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 8 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 26 | (Valorisation Office, 2017) |
| Division of Income: Innovation Fund | 33% | Valorisation Office (2017) |
| Country Venture Capital (Rank) | 20 | (Schwab, 2015) |
| Income from Industry | 51.5M Euro | (van Goethem, 2016) |
| Income from Government | 214M Euro | (van Goethem, 2016) |
| Income from Student Fees | - Euro | (van Goethem, 2016) |
| Income from Investments | 11.7M Euro | (van Goethem, 2016) |
| GDP per Capita (US$) | $41,283.30 | (Schwab, 2015) |
| Division of Income: University | 34% | Valorisation Office (2017) |
| Division of Income: Inventor | 33% | Valorisation Office (2017) |
| Number of Publications (2007 - 2017) | 23,736 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 11.77 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 1991 | (Hanssens, 2016) |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | 2017 | (Hanssens, 2016) |
| Date of Revision: University IP Policy | No Data | N/A |
| Number of Non-Legal Staff at TTO | 180 | (Web of Knowledge, 2017) |
| Number of Spin-Offs | 110 | (Web of Knowledge, 2017) |

**Table D.9:** Data - Ghent University

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 36,453 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 45% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | Belgium | (Schwab, 2015) |
| # of Staff | 5321 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | van den Bosch (89) | (Web of Knowledge, 2017) |
| # of National Patents | 24 | (European Patent Office, 2016) |
| % PCT Patents | 38% | (European Patent Office, 2016) |
| % Success Patents | 38% | (European Patent Office, 2016) |
| University QS Ranking | 138 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R17,400.00 | (Torfs, 2016) |
| Number of Legal Staff | 9 | Valorisation Office (2017) |
| Quality of Country's Science and Education (Rank) | 7 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 8 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 40 | Tech Trensfer (2017) |
| Division of Income: Innovation Fund | No Data | N/A |
| Country Venture Capital (Rank) | 20 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | N/A |
| Income from Student Fees | No Data | N/A |
| Income from Investments | No Data | N/A |
| GDP per Capita (US$) | $41,283.30 | (Schwab, 2015) |
| Division of Income: University | No Data | N/A |
| Division of Income: Inventor | No Data | N/A |
| Number of Publications (2007 - 2017) | No Data | N/A |
| Average Citations per Item (2007 - 2017) | No Data | N/A |
| Date of Release: National IP Policy | 1991 | (Hanssens, 2016) |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | 2017 | (Hanssens, 2016) |
| Date of Revision: University IP Policy | No Data | N/A |
| Number of Non-Legal Staff at TTO | 22 | Tech Trensfer (2017) |
| Number of Spin-Offs | 105 | Tech Trensfer (2017) |

**Table D.10:** Data - Washington State University

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 27,439 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 15% | (Quacquaelli Symonds, 2017) |
| Total Revenue | $45.5M | (Schulz, 2017) |
| Country | USA | (Schwab, 2015) |
| # of Staff | 1997 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Whang (61) | (Web of Knowledge, 2017) |
| # of National Patents | 174 | (European Patent Office, 2016) |
| % PCT Patents | 43% | (European Patent Office, 2016) |
| % Success Patents | 43% | (European Patent Office, 2016) |
| University QS Ranking | 391 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R201,000.00 | Lerner *et al.* (2010) |
| Number of Legal Staff | 8 | (CoMotion, 2017) |
| Quality of Country's Science and Education (Rank) | 10 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 14 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 15 | (CoMotion, 2017) |
| Division of Income: Innovation Fund | 0% | N/A |
| Country Venture Capital (Rank) | 1 | (Schwab, 2015) |
| Income from Industry | $8.2M | (Schulz, 2017) |
| Income from Government | $20.5M | (Schulz, 2017) |
| Income from Student Fees | $11.0M | (Schulz, 2017) |
| Income from Investments | $5.9M | (Schulz, 2017) |
| GDP per Capita (US$) | $57,436.40 | (Schwab, 2015) |
| Division of Income: University | 70% | (CoMotion, 2017) |
| Division of Income: Inventor | 30% | (CoMotion, 2017) |
| Number of Publications (2007 - 2017) | 26,000 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 6.95 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 1980 | (USPTO, 2017) |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | 2017 | (USPTO, 2017) |
| Date of Revision: University IP Policy | 2017 | N/A |
| Number of Non-Legal Staff at TTO | 11 | (CoMotion, 2017) |
| Number of Spin-Offs | 915 | (CoMotion, 2017) |

**Table D.11:** Data - University of North Carolina at Chapel Hill

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 26,211 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 31% | (Quacquaelli Symonds, 2017) |
| Total Revenue | $2,124M | (Folt, 2017) |
| Country | USA | (Schwab, 2015) |
| # of Staff | 4733 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Tucker (61) | (Web of Knowledge, 2017) |
| # of National Patents | 90 | (European Patent Office, 2016) |
| % PCT Patents | 81% | (European Patent Office, 2016) |
| % Success Patents | 81% | (European Patent Office, 2016) |
| University QS Ranking | 83 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R201,000.00 | Lerner *et al.* (2010) |
| Number of Legal Staff | No Data | N/A |
| Quality of Country's Science and Education (Rank) | 10 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 14 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | N/A |
| Division of Income: Innovation Fund | No Data | N/A |
| Country Venture Capital (Rank) | 1 | (Schwab, 2015) |
| Income from Industry | $870M | (Folt, 2017) |
| Income from Government | $811M | (Folt, 2017) |
| Income from Student Fees | $427M | (Folt, 2017) |
| Income from Investments | $16.4M | (Folt, 2017) |
| GDP per Capita (US$) | $57,436.40 | (Schwab, 2015) |
| Division of Income: University | 20% | (Folt, 2017) |
| Division of Income: Inventor | 40% | (Folt, 2017) |
| Number of Publications (2007 - 2017) | 70,771 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 3.59 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 1980 | (USPTO, 2017) |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | 2017 | (USPTO, 2017) |
| Date of Revision: University IP Policy | No Data | N/A |
| Number of Non-Legal Staff at TTO | No Data | N/A |
| Number of Spin-Offs | No Data | N/A |

**Table D.12:** Data - Duke University

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 15,086 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 57% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | USA | (Schwab, 2015) |
| # of Staff | 3,037 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Liu (118) | (Web of Knowledge, 2017) |
| # of National Patents | 783 | (European Patent Office, 2016) |
| % PCT Patents | 34% | (European Patent Office, 2016) |
| % Success Patents | 34% | (European Patent Office, 2016) |
| University QS Ranking | 23 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R201,000.00 | Lerner *et al.* (2010) |
| Number of Legal Staff | 3 | Technology Transfer Office (2018) |
| Quality of Country's Science and Education (Rank) | 10 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 14 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 22 | Technology Transfer Office (2018) |
| Division of Income: Innovation Fund | 30% | Technology Transfer Office (2018) |
| Country Venture Capital (Rank) | 1 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | No Data |
| Income from Student Fees | No Data | No Data |
| Income from Investments | No Data | No Data |
| GDP per Capita (US$) | $57,436.40 | (Schwab, 2015) |
| Division of Income: University | 37% | Technology Transfer Office (2018) |
| Division of Income: Inventor | 33% | Technology Transfer Office (2018) |
| Number of Publications (2007 - 2017) | 84,576 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 2.88 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | 1980 | (USPTO, 2017) |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | 2017 | (USPTO, 2017) |
| Date of Revision: University IP Policy | 2018 | Technology Transfer Office (2018) |
| Number of Non-Legal Staff at TTO | 43 | Technology Transfer Office (2018) |
| Number of Spin-Offs | 63 | Technology Transfer Office (2018) |

**Table D.13:** Data - Qatar University

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 9,189 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 7% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | Qatar | (Schwab, 2015) |
| # of Staff | 1,046 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Meshin (15) (118) | (Web of Knowledge, 2017) |
| # of National Patents | 14 | (European Patent Office, 2016) |
| % PCT Patents | 43% | (European Patent Office, 2016) |
| % Success Patents | 43% | (European Patent Office, 2016) |
| University QS Ranking | 332 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R69,516 | Lerner *et al.* (2010) |
| Number of Legal Staff | No Data | N/A |
| Quality of Country's Science and Education (Rank) | 6 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 22 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | Technology Transfer Office (2018) |
| Division of Income: Innovation Fund | 33% | Technology Transfer Office (2018) |
| Country Venture Capital (Rank) | 5 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | No Data |
| Income from Student Fees | No Data | No Data |
| Income from Investments | No Data | No Data |
| GDP per Capita (US$) | $60,786.70 | (Schwab, 2015) |
| Division of Income: University | 34% | Technology Transfer Office (2018) |
| Division of Income: Inventor | 33% | Technology Transfer Office (2018) |
| Number of Publications (2007 - 2017) | 12,135 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 2.04 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | No Data | N/A |
| Date of Release:University IP Policy | 2008 | Office of Academic Research (2013) |
| Date of Revision: National IP Policy | No Data | N/A |
| Date of Revision: University IP Policy | 2008 | Office of Academic Research (2013) |
| Number of Non-Legal Staff at TTO | No Data | N/A |
| Number of Spin-Offs | No Data | N/A |

**Table D.14:** Data - Australian Nation University

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 16,677 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 41% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | Australia | (Schwab, 2015) |
| # of Staff | 1,638 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Kivshar (91) | (Web of Knowledge, 2017) |
| # of National Patents | 82 | (European Patent Office, 2016) |
| % PCT Patents | 21% | (European Patent Office, 2016) |
| % Success Patents | 21% | (European Patent Office, 2016) |
| University QS Ranking | 24 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R413,000.00 | Lerner *et al.* (2010) |
| Number of Legal Staff | 1 | (Technology Transfer Office, 2017) |
| Quality of Country's Science and Education (Rank) | 30 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 17 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | N/A |
| Division of Income: Innovation Fund | 33% | (Technology Transfer Office, 2017) |
| Country Venture Capital (Rank) | 40 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | No Data |
| Income from Student Fees | No Data | No Data |
| Income from Investments | No Data | No Data |
| GDP per Capita (US$) | $51,850.30 | (Schwab, 2015) |
| Division of Income: University | 34% | Technology Transfer Office (2017) |
| Division of Income: Inventor | 33% | Technology Transfer Office (2017) |
| Number of Publications (2007 - 2017) | 45,156 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 5.36 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | No Data | N/A |
| Date of Release:University IP Policy | 2008 | (Technology Transfer Office, 2017) |
| Date of Revision: National IP Policy | 2008 | Government of Australia (2017) |
| Date of Revision: University IP Policy | 2017 | (Technology Transfer Office, 2017) |
| Number of Non-Legal Staff at TTO | 2017 | Government of Australia (2017) |
| Number of Spin-Offs | 6 | (Technology Transfer Office, 2017) |

**Table D.15:** Data - University of New South Wales

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 40,326 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 28% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | Australia | (Schwab, 2015) |
| # of Staff | 2,930 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Whang (59) | (Web of Knowledge, 2017) |
| # of National Patents | 8 | (European Patent Office, 2016) |
| % PCT Patents | 25% | (European Patent Office, 2016) |
| % Success Patents | 25% | (European Patent Office, 2016) |
| University QS Ranking | 45 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R413,000.00 | Lerner *et al.* (2010) |
| Number of Legal Staff | 1 | (UNSW, 2018) |
| Quality of Country's Science and Education (Rank) | 30 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 17 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | No Data | N/A |
| Division of Income: Innovation Fund | 33% | (UNSW, 2018) |
| Country Venture Capital (Rank) | 40 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | No Data |
| Income from Student Fees | No Data | No Data |
| Income from Investments | No Data | No Data |
| GDP per Capita (US$) | $51,850.30 | (Schwab, 2015) |
| Division of Income: University | 34% | (UNSW, 2018) |
| Division of Income: Inventor | 33% | (UNSW, 2018) |
| Number of Publications (2007 - 2017) | 67,258 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 2.91 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | No Data | N/A |
| Date of Release:University IP Policy | 2008 | (UNSW, 2018) |
| Date of Revision: National IP Policy | 2013 | Government of Australia (2017) |
| Date of Revision: University IP Policy | 2017 | (UNSW, 2018) |
| Number of Non-Legal Staff at TTO | 2018 | Government of Australia (2017) |
| Number of Spin-Offs | 7 | (UNSW, 2018) |

**Table D.16:** Data - Imperial College London

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 16,797 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 43% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | England | (Schwab, 2015) |
| # of Staff | 3,883 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Whang (59) | (Web of Knowledge, 2017) |
| # of National Patents | 11 | (European Patent Office, 2016) |
| % PCT Patents | 36% | (European Patent Office, 2016) |
| % Success Patents | 36% | (European Patent Office, 2016) |
| University QS Ranking | 8 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R351,934.35 | Lerner *et al.* (2010) |
| Number of Legal Staff | 8 | (Technology Transfer Office, 2015) |
| Quality of Country's Science and Education (Rank) | 41 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 7 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 8 | N/A |
| Division of Income: Innovation Fund | 33% | (Technology Transfer Office, 2015) |
| Country Venture Capital (Rank) | 12 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | No Data |
| Income from Student Fees | No Data | No Data |
| Income from Investments | No Data | No Data |
| GDP per Capita (US$) | $40,095.90 | (Schwab, 2015) |
| Division of Income: University | 34% | (Technology Transfer Office, 2015) |
| Division of Income: Inventor | 33% | (Technology Transfer Office, 2015) |
| Number of Publications (2007 - 2017) | 96,535 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 2.91 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | No Data | N/A |
| Date of Release:University IP Policy | 1988 | (Technology Transfer Office, 2015) |
| Date of Revision: National IP Policy | No Data | N/A |
| Date of Revision: University IP Policy | 2015 | (Technology Transfer Office, 2015) |
| Number of Non-Legal Staff at TTO | 18 | (Technology Transfer Office, 2015) |
| Number of Spin-Offs | 59 | (Technology Transfer Office, 2015) |

**Table D.17:** Data - University of Zurich

| Variable | Data | Reference |
|---|---|---|
| Number of Students | 26,472 | (Quacquaelli Symonds, 2017) |
| % Post Graduate Students | 49% | (Quacquaelli Symonds, 2017) |
| Total Revenue | No Data | N/A |
| Country | Switzerland | (Schwab, 2015) |
| # of Staff | 5,160 | (Quacquaelli Symonds, 2017) |
| Top Researcher(h-index) | Gunthard (60) | (Web of Knowledge, 2017) |
| # of National Patents | 105 | (European Patent Office, 2016) |
| % PCT Patents | 42% | (European Patent Office, 2016) |
| % Success Patents | 42% | (European Patent Office, 2016) |
| University QS Ranking | 78 | (Quacquaelli Symonds, 2017) |
| Cost of Patent | R13,410.00 | Lerner *et al.* (2010) |
| Number of Legal Staff | 1 | Unitectra (2017) |
| Quality of Country's Science and Education (Rank) | 3 | (Schwab, 2015) |
| Quality of IPR System (Rank) | 1 | (Schwab, 2015) |
| Current Number of Spin-Off Companies | 143 | N/A |
| Division of Income: Innovation Fund | 33% | Unitectra (2017) |
| Country Venture Capital (Rank) | 15 | (Schwab, 2015) |
| Income from Industry | No Data | N/A |
| Income from Government | No Data | No Data |
| Income from Student Fees | No Data | No Data |
| Income from Investments | No Data | No Data |
| GDP per Capita (US$) | $79,242.30 | (Schwab, 2015) |
| Division of Income: University | 34% | Unitectra (2017) |
| Division of Income: Inventor | 33% | Unitectra (2017) |
| Number of Publications (2007 - 2017) | 49,915 | (Web of Knowledge, 2017) |
| Average Citations per Item (2007 - 2017) | 11,09 | (Web of Knowledge, 2017) |
| Date of Release: National IP Policy | No Data | N/A |
| Date of Release:University IP Policy | No Data | N/A |
| Date of Revision: National IP Policy | No Data | N/A |
| Date of Revision: University IP Policy | No Data | N/A |
| Number of Non-Legal Staff at TTO | 14 | Unitectra (2017) |
| Number of Spin-Offs | 206 | Unitectra (2017) |

# Appendix E

# Interviews

**Table E.1:** Interview - University of the Free-State

| Variable | Data |
|---|---|
| Entity | University Technology Transfer Office |
| Position | Director |
| Background | Mechanical Engineer + Law<br>Worked at InnovUS |
| Model Opinion | Accept Model |
| Measure of Success | Increase academic foot print |
| Ratio (Legal/Commercial) | 1:8 |
| Focus on IPR | Patent filing last resort |
| Source of Funding Mentioned | Industry Partners |

**Table E.2:** Interview - North West University

| Variable | Data |
|---|---|
| Entity | University Technology Transfer Office |
| Position | Technology transfer Consultant |
| Background | Law |
| Model Opinion | Accept Model |
| Measure of Success | Increase funding for research |
| Ratio (Legal/Commercial) | 1:3 |
| Focus on IPR | Patents used for obtaining funding from TIA |
| Source of Funding Mentioned | TIA |

**Table E.3:** Interview - University of Pretoria

| Variable | Data |
|---|---|
| Entity | University Technology Transfer Office |
| Position | Commercialisation Manager |
| Background | Marketing<br>Lawrence Baloyi (Head of Department)<br>Worked for InnovUS |
| Model Opinion | Accept Model |
| Measure of Success | Funding for additional research recieved |
| Ratio (Legal/Commercial) | 1:1 |
| Focus on IPR | Patent filing when commercial potential is identified |
| Source of Funding Mentioned | TIA |